Updated analysis on Mexico's GHG baseline, marginal abatement cost-curve and project portfolio

MEXICO LOW EMISSIONS DEVELOPMENT PROGRAM (MLED).

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Updated analysis on Mexico's GHG baseline, marginal abatement cost- curve and project portfolio

This study was prepared by McKinsey & Company under the supervision of Antonio Mediavilla and Ricardo Troncoso of WWF Mexico, within the framework of the Mexico Low Emissions Development Program (MLED), sponsored by the United States Agency for International Development (USAID), under the contract "AID-523-C-11-00001" implemented by TETRA TECH ES INC.

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Table of acronyms and abbreviations

A/R	Afforestation/reforestation
BAU	Business as Usual scenario, or baseline
BRT	Bus rapid transit, a system of urban transportation giving preference to public buses
CAGR	Compound annual growth rate
Capex	Capital expenditure or investment rather than a cost
CCS	Carbon Capture and Storage
CDM	Clean Development Mechanism of the Kyoto Protocol
CFL	Compact fluorescent lamp, an energy-saving light-bulb
CH_4	Methane
CNG	Compressed natural gas
CO_2	Carbon dioxide, the most important greenhouse gas
CO_2e	Carbon dioxide equivalent, a unit that converts other greenhouse gases to an equivalent amount of CO2
CONAFOR	Comisión Nacional Forestal
CONUEE	Comisión Nacional para el Uso Eficiente de la Energía
COP	Conference of the Parties, the annual summit of the United Nations Framework Convention on Climate Change
CRE	Comision Reguladora de Energia
CTS	Centro de Transporte Sustentable
FONADIN	Fondo Nacional de Infraestructura
GDP	Gross Domestic Product
GHG	Greenhouse gases (mainly carbon dioxide, methane, and nitrous oxide)
GW	Gigawatt
GWh	Gigawatt hour of electricity
Ha	Hectares
HDV	Heavy-duty vehicle on road, weighing more than 16 tons
HFCs	Hydrofluorocarbons
INECC	Instituto Nacional de Ecología y Cambio Climático
INEGEI	Inventario Nacional de Emisiones de Gases de Efecto Invernadero
INEGI	Instituto Nacional de Estadística y Geografía
IPCC	Intergovernmental Panel on Climate Change
LDV	Light-duty vehicle, weighing less than 3 tons
Lm	Lumen
MEDEC	México: Estudio de la Disminuación de Emisiones de Carbono
MDV	Medium-duty vehicle on road, weighing between 3 and 16 tons
MtCO2e	Million metric tons of carbon dioxide equivalent
MW	Megawatt of installed power generation capacity
MWh	Megawatt hour of electricity
N_2O	Nitrous oxide, a greenhouse gas
Opex	Operating expenditure or cost
PECC	Programa Especial de Cambio Climático
PEMEX	Pétroleo Mexicano
POISE	Programa de Obras e Inversiones del Sector Eléctrico
PV	Solar Photovoltaic
SAGARPA	Secretaría de Agricultura Ganaderia, Desarrollo Rural, Pesca y Alimentacion
SCT	Secretaría de Comunicaciones y Transported
SEMARNAT	Secretaría de Medio Ambiente u Recursos Naturales
SENER	Secretaría de Energía
SIACON	Sistema de Información Agroalimentaria de Consulta
SIAP	Servicio de Información Agroalimentaria y Pesquera
SLCFs	Short-Lived Climate Forcers

TWh	Terawatt hour of electricity

Abstract

As part of the Mexico Low Emissions Development Program, this project was established to develop an updated GHG emissions baseline, a GHG abatement cost-curve to identify potential emission mitigation actions, and finally capture existing efforts in a project portfolio database.

In the Business as Usual (BAU) scenario, Mexico's GHG emissions could increase by 3.4% annually up to 2030, from 727 MtCO2e in 2010 to 954 MtCO2e in 2020 and 1,332 MtC02e by 2030.

By 2020, Mexico can achieve its internationally committed emission reduction target and reduce its annual emissions by 320 MtC02e (33% of the baseline emissions) if it fully implements all 129 identified abatement levers. Implementing ten technologies alone would capture 55% of the total abatement potential by 2020. However, only 52 MtC02e of abatement potential is captured in existing or planned climate mitigation projects.

The project included the transfer of the abatement cost-curve models to the technical staff at Instituto Nacional de Ecología y Cambio Climático (INECC) as well as intensive training in the use of the models. The project further created a mitigation project database and tracking tool.

Executive Summary

In recent years, the Government of Mexico, through the Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT) and the Instituto Nacional de Ecología y Cambio Climático (INECC), has made various efforts in reducing emissions of greenhouse gases (GHG) such as the 2009 Mexico GHG abatement cost-curve.

As part of the cooperative efforts on climate change between the Governments of United States and Mexico, through the Mexico Low Emissions Development Program (MLED), the task was given to McKinsey & Company in cooperation with SEMARNAT and INECC to update the analysis on Mexico's GHG baseline, construct a new GHG abatement cost-curve, and create a portfolio of mitigation projects.

With this report, previous efforts have been reviewed, updated, and strengthened with the purpose of serving as an input to the development and implementation of Programa Especial de Cambio Climático (PECC), which will be published later in 2013.

The project included the transfer of the abatement cost-curve models to the technical staff at INECC as well as intensive training in the use of the models. The project further created a mitigation project database and tracking tool, which also has been transferred to the INECC staff.

Results

In the BAU scenario, Mexico's GHG emissions could increase by 3.4% annual up to 2030, from 727 MtCO2e[1] (megatons or million metric tons of carbon dioxide equivalent) in 2010 to 954 MtCO2e in 2020 and 1,332 MtC02e by 2030. This would translate into per capita emissions of ~10 tons per person per year by 2030, in a time when the world ought to decrease emissions to an average 2 tons per person per year to limit global warming to 2° Celsius. It should be mentioned that the baseline has been significantly updated to the 2009 GHG cost-curve. As such, the new baseline is defined based on January 1, 2010, which means that any mitigation project that was in place before this date is considered as part of the baseline and not abatement. Particularly in the power sector, it means that the baseline is rather green, as Programa de Obras e Inversiones del Sector Eléctrico (POISE) 2010 is mainly based on an energy mix from gas combined cycle and also introduces renewable energies, such as wind and large hydro.

Yet, by choosing a low-emission development path, there is potential for a much larger reduction in emission intensity and a substantial abatement of GHG emissions. Having defined Mexican emissions under BAU assumptions, we have identified a wide range of options to reduce GHG emissions across all sectors of the economy.

By 2020, Mexico can reduce its annual emissions by up to 33% compared to the results in the BAU scenario if Mexico fully implements all 126 identified technical abatement levers and three policy measures. As a consequence, Mexico can achieve its COP15 committed target of 30% emission reduction versus baseline. This entails reducing the annual emissions by 320 MtCO2e compared to the BAU scenario in 2020, to reach an emission level of ~ 634 MtCO2e or around 90% of emissions in 2010.

The environmental benefits identified could have a positive impact on the Mexican economy. Many of the abatement measures examined are net-profit-positive to the economy—i.e., they are beneficial to the economy as a whole. An example of a net-profit-positive measure is fuel efficiency improvements in light-duty vehicles (LDVs), for which the increased up-front cost of the technology improvements is more than compensated for by the savings in fuel consumption costs.

On average, the abatement potential comes at a net-profit-positive gain of USD 36 for every ton of CO2e that gets abated compared to the BAU scenario, with 59% abatement potential achievable at net-profit-positive gain. The remaining 31% of abatement potential comes at a cost to Mexico

[1] Excluding HFCs

compared to the BAU scenario. The total net cost to the economy of implementing all technical measures is overall positive to the economy in 2020. Hence, should all measures be implemented, savings from the net-profit-positive abatement measures would cancel out the costs of the others.

85% of the emission abatement potential in 2020 is concentrated in five sectors: forestry, transport, power, oil and gas, and waste. These are the key sectors of the climate agenda for Mexico, offering great impact in terms of carbon abatement as well as economic and social development.

- The forestry sector holds almost 25% of the maximum abatement potential. Current estimates suggest that Mexico could transform the sector into a net carbon sink. While acknowledging significant data uncertainties, estimations of current net emissions add up to ~ 50 MtCO2e and are expected to stay constant until 2020 under BAU assumptions. By implementing all abatement measures, Mexico could turn the forestry sector into a carbon sink that sequesters up to ~ 22 MtCO2e by 2020 at an estimated average cost of ~ USD 31/tCO2e without taking into account the significant co-benefits that exist in the sector. This maximum abatement potential is mainly driven by reducing deforestation (70%) and 30% of the potential comes from increasing afforestation and reforestation (A/R)
- The transport sector has the potential to reduce GHG emissions from burning fossil fuels by 20% compared to the BAU scenario in 2020, equaling a total abatement potential of 55 MtCO2e in 2020. 54% of the abatement potential (30 MtCO2e) is derived from fuel efficiency measures primarily targeting LDVs. 24% of abatement (13 MtCO2e) is driven by modal shifts to public and freight transport. 15% of abatement (8 MtCO2e) comprises policy measures, i.e., vehicle mix, scrapping program, and ban of imported cars. Around 70% of the transport levers are net-profit-positive
- The power sector holds around 17% of Mexico's maximum abatement potential. Annual emissions in the sector could be reduced by 36% compared to the BAU scenario by 2020, dropping from an annual 152 MtCO2e to only 97 MtCO2e. 31% of abatement (17 MtCO2e) is derived from geothermal power generation. 16% of abatement (9 MtCO2e) comprises small hydro generation. Remaining abatement contribution (29 MtC02e) is from other renewable sources, e.g., wind, reduction of transmission losses, and shift within fossil fuels. Around 70% of the power levers are net-profit-positive. Net-profit-negative levers such as wind and solar PV have seen a severe decrease in cost versus traditional technologies, but are with current projections not yet fully cost competitive
- The oil and gas and waste sectors can, in combination, contribute almost 30% of the abatement potential. The largest abatement opportunities are a reduction of gas flaring; recycling new waste; cogeneration in Pemex's refineries and wastewater improved treatment. More than 90% of oil and gas abatement levers and 70% of waste levers come at an overall financial gain to the society

Implementing ten measures with the largest abatement potential would capture 55% of the total abatement potential by 2020. These ten measures are:

1. Reduced deforestation from pastureland conversion (30 MtCO2e)
2. Reduced flaring (24 MtC02e)
3. Recycling new waste (23 MtC02e)
4. LDV fuel efficiency (20 MtCO2e)
5. Reduced deforestation from slash & burn agriculture conversion (20 MtC02e)
6. Geothermal (17 MtC02e)
7. Cogeneration—downstream in oil and gas (13 MtC02e)
8. Wastewater—improved treatment (12 MtC02e)
9. Degraded forest reforestation (9 MtCO2e)
10. Small hydro (9 MtC02e)

52 MtCO2e, or 16% of the abatement potential by 2020, is captured in emission mitigation projects. We developed a project portfolio database during the project, based on publicly available information. The largest potential is captured in the oil and gas and transport sectors, which have captured respectively 30% and 18% of their total abatement potential. However, only 28% of the net-profit-positive potential is currently captured in projects indicating a large opportunity to accelerate the agenda. The largest untapped opportunities are reduction of deforestation from pastureland and slash & burn agriculture conversion, recycling of new waste, and geothermal.

The results in this project arise from a process of assessing more than 200 potential abatement levers and deciding on 129 with a significant potential for abatement. All 129 levers were assessed for potential and cost, based on a broad assessment of data sources from public, private, national and international sources, e.g., CONAFOR, FONADIN, GDF, PECC, SCT, POISE, CRE, PEMEX, SEMARNAT, CDM projects, SAGARPA, and many international databases. In general, we prioritized official Mexican Government data, when available, over all other data sources. All data input was further validated by INECC working team members, local sector experts, and with more than 50 of our global experts on the specific sectors. Throughout the process, we have further identified hundreds of current or planned emission mitigation projects, which are documented in a project portfolio tracking tool and as well in communication templates. The baseline and abatement potentials are calculated for the years 2015, 2020, 2025 and 2030; however for simplifying communications this report focuses on 2020, which is the year of the committed abatement target.

All the estimates that determine the abatement potential are based on the collective experience and expertise of various working groups at INECC, as well as experts from the public and private sectors. Through more than 20 training sessions and 30 content meetings, we jointly developed the results as stated in this report.

Finally, it should be stated that the results described in this report reflects stretched potentials within the boundary of what the INECC working teams thought would be technically achievable by the given timelines.

Introduction

The abatement cost-curves are useful tools for prioritization, communication, and decision making, and can lead to the development of a strategy for low-carbon development. This project was established to update previous baseline and abatement cost-curve efforts as well as develop an integrated project database of existing or planned activities to mitigate GHG emissions.

Another important aspect was to build the capabilities at INECC in the use of the cost-curves to ensure continuous updates of the tools for input to policy making. As a result, we conducted more than 20 trainings across the 11 sectors to dedicated sector teams within INECC. We further trained three people to become "super users" of the cost-curves.

The objective of this project was to:

- Collect a **portfolio of mitigation projects** that are either planned or have been implemented to be able to track the process towards the 2020 target of 30% emission reduction versus targets
- Plan and develop a methodology for the construction of the **abatement cost-curves**
- Conduct a **cost-benefit analysis** of the project portfolio, which includes the capital and Opex cost but also the abatement potential
- **Develop the actual abatement cost-curves** and build the associated cost-curves for different time scenarios (2015, 2020, 2025, and 2030), that would consider different scenarios of key economy indicators, such as the price of oil and gas
- Organize **knowledge transfer workshops and develop training material**, so that future updates of the cost-curve can be made by the staff at INECC

This report includes an overview of the approach, methodology, and results of the efforts as well as a summary of recommended next steps. The report focuses on the abatement potential of the year 2020. Detailed documentation of sector results and emission mitigation projects for 2020 is included as appendices to this report. The actual baseline and cost-curves are calculated to 2030 and the results are shown in the supporting power point presentation.

Background

This project builds on the following work that McKinsey has previously conducted in Mexico:

- "Low Carbon Growth, a Potential Path for Mexico" which closed the gap in the existing knowledge base in Mexico and contributed to the first PECC
- "Assessing the feasibility to capture the identified abatement potential for Mexico"—in this initiative, we assessed the feasibility of the adoption and implementation of public policies on GHG and, moreover, identified priority areas to achieve greater impact
- With "Mexico's Long-Term Mitigation Strategy" we defined mitigation plans for 2020 and 2030, which had detailed mitigation potential by sector and identified the problems of applying the relevant abatement levers
- The "Revision of Emissions' Baseline" allowed for a detailed calculation of the baseline, integrating local officials in the projection of the relevant variables

This project is aiming to answer two key questions for the climate change agenda in Mexico:

- Can Mexico deliver on its 30% emission reduction target set in COP15 in Copenhagen?
- How much of the emission reduction target is captured in current or planned projects?

Methods

The Mexico abatement cost-curve describes the GHG abatement potential of 126 technologies. We refer to these as technical abatement levers. The cost-curve further includes three policy measures. The cost of implementing the technical abatement levers is calculated using McKinsey's methodology, adjusted to take into account the specific characteristics of the Mexican economy. The abatement cost-curve thus serves as a fact base that quantifies Mexico's abatement potential and the cost of capturing that potential, and can be used to assist policy makers to set and test Mexico's abatement objectives. The cost-curve analyzes abatement levers in eleven industry sectors. There are three stages to the analysis:

1. An evaluation of the GHG emission levels that can be expected up to 2030 if no new government measures or regulations are introduced to reduce emissions other than those already announced or implemented by January 1, 2010. This evaluation constitutes the BAU emissions scenario, which is used as the baseline for measuring the abatement potential of the various technical abatement levers
2. Identification of a range of technical levers capable of reducing GHG emissions, and a quantification of the abatement potential and the implementation cost of each lever
3. Integration of all the levers into a GHG abatement cost-curve to demonstrate the abatement potential and the cost of capturing that potential, both at the broad economy level and within individual sectors

Construction of the BAU emissions scenario

The BAU scenario reflects the likely growth of GHG emissions in Mexico from 2010 to 2030, taking into account government policy and regulations as of January 1, 2010. This scenario serves as a baseline for comparing other abatement scenarios presented below. For the purpose of the BAU scenario, Mexico's economy was grouped into eleven sectors: agriculture, buildings, cement, chemicals, iron & steel, forestry, oil and gas, other industry, power, transport, and waste.

The likely emissions from each sector were calculated taking into account fuel consumption, electricity consumption, and process-related emissions (such as emissions from chemical processes). The likely growth in emissions between 2010 and 2030 were factored in, taking into account forecast economic changes (GDP growth, population growth, new technologies, etc.); operational changes (such as the shift to gas in the power baseline according to POISE 2010); and the more efficient use of energy.

Subsequent analysis of the technical abatement levers

The 126 technical levers appropriate to Mexico's economy were first identified out of a total group of more than 200 levers. Their abatement potential and the cost of implementation were then analyzed.

A team from McKinsey worked with INECC experts to identify the levers appropriate to the Mexico economy. The levers reviewed included power generation technologies that use renewable energy; alternative fuels; and energy efficiency levers—for example, levers that improve insulation in buildings or reduce electric power consumption. The majority of levers analyzed used commercially-proven technologies. Only a few, newer technologies in the final stages of development were included. Technologies in the early stages of development were excluded.

The abatement potential of each of the levers was calculated as the total emissions that would be prevented through the use of the lever over the course of one year. For example, the abatement potential of switching to energy-saving light bulbs—compact fluorescent lamps (CFLs)—was calculated as the difference between the total emissions from CFLs and incandescent light bulbs over a year.

The cost of implementation of each of the levers was also calculated in relation to BAU practices. The annual cost of each lever is the cost of the initial investment or capital expenses (including financing costs, and capitalized over the life span of the lever at an annual interest rate of 4%), plus the annual current operating expenses, less the annual savings captured by using the lever. So for example, the cost of using energy-saving light bulbs was calculated as the annual added cost of purchasing the light bulbs compared with using incandescent light bulbs, less the annual savings gained from using less electricity. The overall abatement cost is the cost (in USD) required for the abatement of one ton of GHG (USD/tCO2e). The abatement cost of a lever is, therefore, the implementation cost divided by the GHG emissions prevented by the use of the lever (the abatement potential). For example, the abatement cost of GHG abatement potential in energy-saving light bulbs is calculated as the cost of implementing the lever, divided by the abatement captured from its implementation.

It is important to note that the abatement costs are calculated as costs to society as a whole, as there is no attempt to analyze who bears the costs and who enjoys the financial benefits. We assume, however, that the costs will remain constant whether they are subsidized by the government, transferred to the consumer, or borne by industry. In addition, the costs presented in the report represent only direct costs. In other words, they include most of the costs related to the implementation of the levers, but do not include any indirect, additional costs and/or benefits, such as the cost of supervising implementation or the costs that would result from doing nothing.

The following three exhibits show how abatement cost is being calculated:

Exhibit 1

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Calculation logic and assumptions for the abatement cost

$$\text{Abatement cost} = \frac{[\text{Full cost of } CO_2e \text{ efficient alternative}] - [\text{Full cost of BAU/reference solution}]}{[CO_2e \text{ emissions from BAU/reference solution}] - [CO_2e \text{ emissions from alternative}]}$$

Full cost includes ...

- Investment costs calculated with economic amortization period and capital costs (like a repayment of a loan)
- Operating costs, incl. personnel/materials costs
- Possible cost savings generated by the actions (especially energy savings)

Full cost does not include...

- Transaction costs
- Communication/information costs
- Subsidies
- Taxes
- Explicit CO_2 costs
- Consequential impact on the economy (e.g., advantages from technology leadership)

Other assumptions

- Abatement costs for new technologies are consistently compared to the specific cost and emission intensity of displaced alternatives
- Full costs can be negative, i.e., indicating a net benefit deriving from the use of the solution

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Exhibit 2

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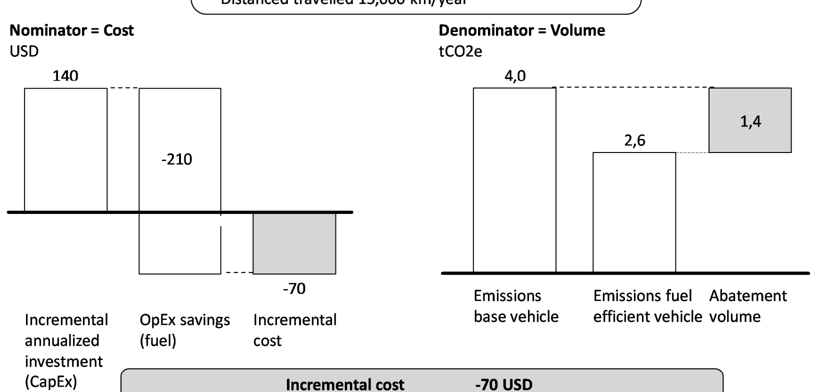
Abatement cost calculation - Illustrative transport example with simplified numbers

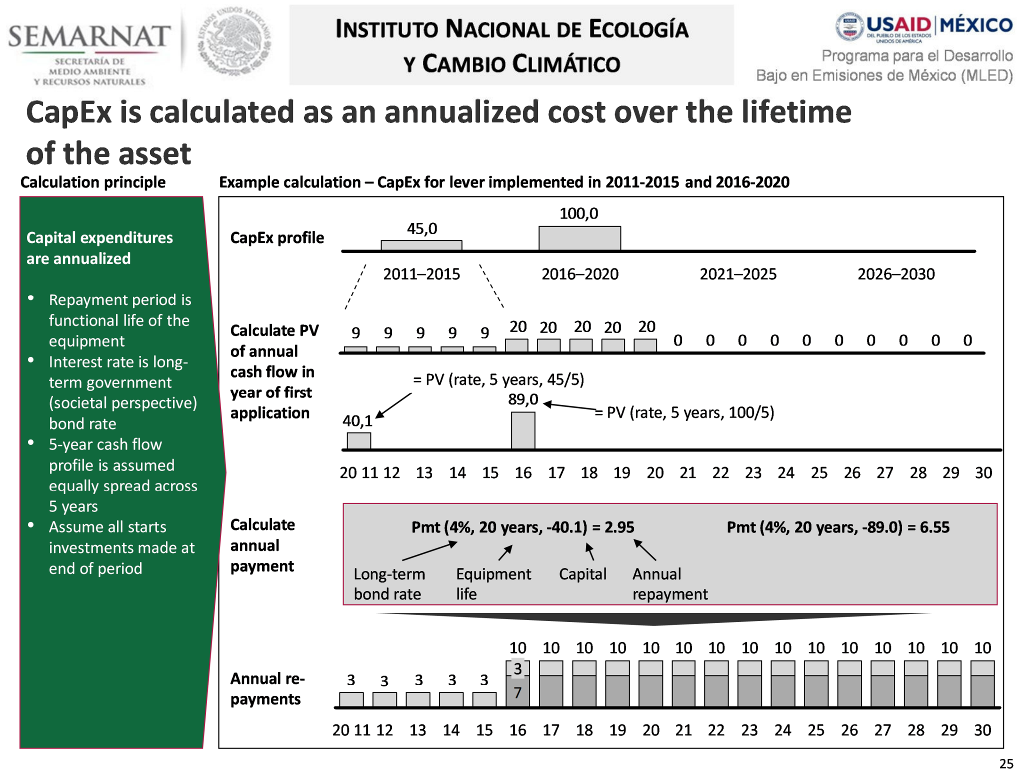
- Incremental bundle cost : USD 1,200
- Fuel consumption reduction: 35% (from 10 l/100km)
- Gasoline price (societal perspective) 0.40 USD/l
- Lifetime 15 years
- Interest rate 8%
- Distanced travelled 15,000 km/year



$$\text{Abatement cost} = \frac{\text{Incremental cost}}{\text{Abatement volume}} = \frac{-70 \text{ USD}}{1{,}4 \text{ tCO2e}} = -50 \text{ USD/tCO2e}$$

20

Exhibit 3



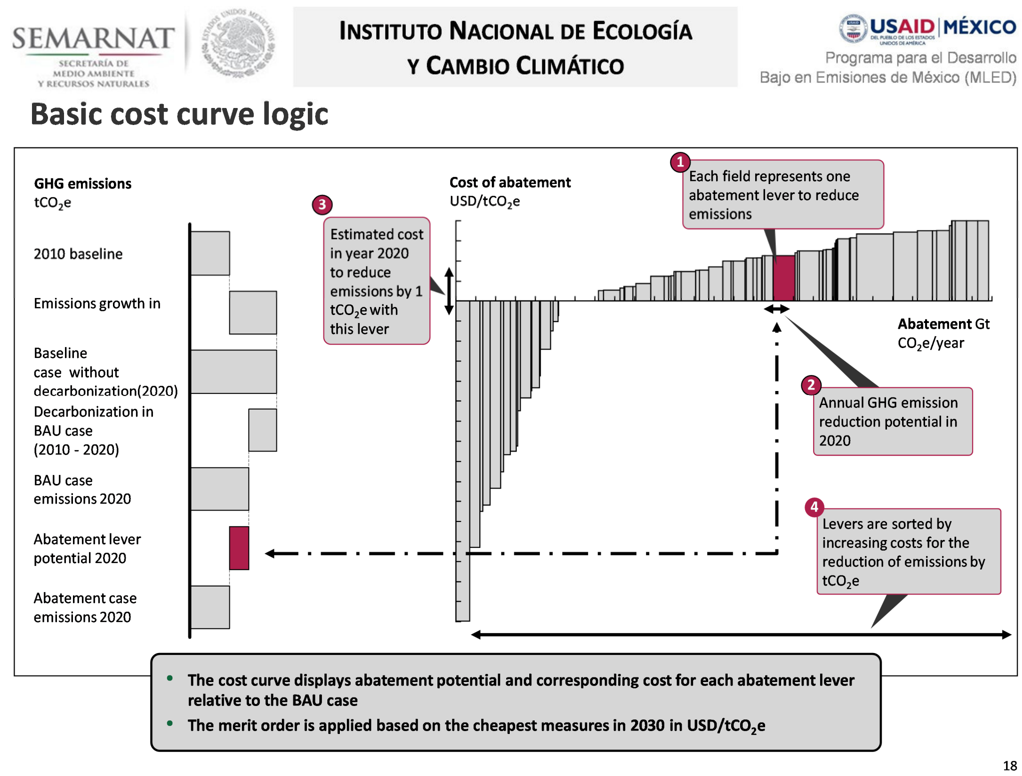
Integration of the levers into the abatement cost-curve

The cost-curve takes into account of the impact each lever has on the entire economy. For example, it takes into account the impact electric vehicles (EVs) will have on power supply. This gives an integrated view of Mexico's abatement potential and the cost of capturing that potential. It should be noted that the order in which the levers are implemented can impact the abatement potential. For example, levers which reduce demand for electricity also reduce the amount of power generated, which in turn reduces the abatement potential in the power industry that would otherwise result from changing the fuel blend (i.e., by using more renewable energy). Abatements are allocated to the industry that implements the lever. For example, the switch to energy-saving light bulbs saves emissions from electric power generation. However, the abatement is allocated to the buildings sector where the bulbs are used, not the power sector. For the purpose of the analysis, certain assumptions were made about factors such as future electricity costs, fuel costs, technology costs, and learning curves. Where necessary, insights gained from McKinsey's work in other countries were adapted for Mexico (for example, the speed of market penetration of EVs). Data unique to Mexico's economy were also factored in. For details of the principal weighted assumptions in the analysis of the various sectors, see the appendix at the end of this report. The overall abatement potential is not a forecast, as actual abatement will depend upon the extent to which the levers described are implemented.

How to read the abatement cost-curve

The levers are classified according to their cost to the economy in 2020. This cost is described on the vertical axis of the cost-curve. A lever with a negative cost (economic savings) will appear below the horizontal axis. A lever with a positive cost will appear above it. The cost of the lever is represented in units of USD/tCO2e—i.e., the cost in USD of the abatement of one ton of GHG. The horizontal axis of the cost-curve represents the abatement potential of each lever—i.e., the emissions abated relative to the BAU scenario. The width of the entire curve represents the total abatement potential from implementation of all levers. The area of the entire curve represents the total costs or savings resulting from the full use of all levers in the year described in the curve.

Exhibit 4



It is important to note that the cost-curve describes a dynamic abatement scenario—that is, the 2020 cost-curve shows a cross section for that year, assuming that all the levers described will have been implemented in a timely manner between 2011 and 2020.

How to interpret the abatement cost-curve

The cost-curve illustrates abatement opportunities ("supply"). The curve adopts a "Societal perspective", illustrating cost requirements to the society over a long time horizon. Hence, the discount rate of 4% for capital expenditures is based on long-term bond rates, indicative of interest rates in market. Assumed lifetime of assets is based on real average life length, not on shorter depreciation horizon of the decision maker.

The cost-curve does not illustrate abatement requirements ("demand"). The curve does not show a "decision maker's" perspective which would require a discount rate equal to the typical company WACC for capital expenditures, taking into account taxes, subsidies, etc.

Results

The project comprises three core elements—BAU emission estimates; the abatement potential and associated cost, and finally a mitigation project portfolio. The project timeline expands to 2030 with a focus on 2020, as Mexico has made international emission reduction commitments at this timeline.

Under a BAU scenario, GHG emissions are expected to grow at about 3% annually to reach 954 MtCO2e by 2020

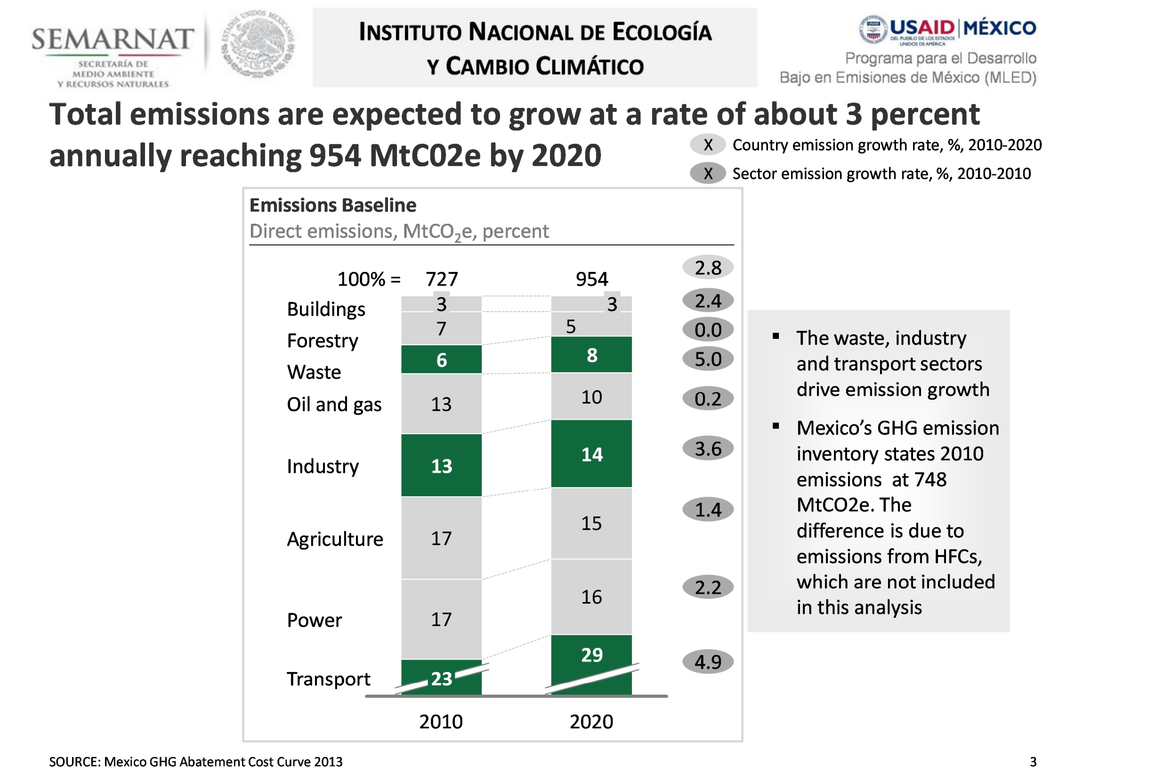
In 2010, Mexico emitted 727 MtCO2e[2]. This translates into ~ 6.5 MtCO2e per person per year. This means that Mexico is already emitting more than is sustainable—in order to limit the effects of climate change, the world must aspire to a level in the range of 1 to 2 tCO2e per person per year.

Mexico's GHG emissions come from a wide range of sources spread across all sectors of the economy, but 84% is attributable to only five sectors transport; power; agriculture; industry; and oil and gas. The transport sector has the highest level of emissions. The burning of fuels in cars, trucks and other motorized vehicles is responsible for ~ 23% of total emissions with the vast

2 Ibid

majority coming from the road transport sector. The sector with the second-highest level of emissions is power: 17% of Mexico's emissions are caused by the burning of fossil fuels for power generation. The agricultural sector causes a similar amount of emissions: ~ 126 MtCO2e per year, equaling 17% of Mexico's total emissions, mainly in the form of methane and other GHG that are released in cattle farming and the cultivation of crops. Together, these top three sectors account for almost 60% of the total emissions.

Exhibit 5



All other sectors account for the remaining 40% of GHG emissions, with the industry sectors (cement, chemicals, iron & steel, and other industries) and oil and gas being the next most important sources.

The results show that, if Mexico's development is to follow BAU, the annual emissions in 2020 would be more than 30% higher than they were in 2010, reaching ~ 954 MtCO2e. In per capita terms, this entails an increase from ~ 6.5 CO2e per capita per year to ~ 8.0 tons of CO2e per capita per year. If Mexico wants to reach the world average of emissions per person required to keep carbon concentration in the atmosphere at 450 ppm , Mexico needs to limit its emissions to ~ 250 MtCO2e per year—or almost one fourth of the amount that Mexico would reach by 2020 in the BAU scenario.

The BAU scenario—background and assumptions

To identify the main drivers of future emissions, it is essential to gain a clear picture of how emissions would develop in each sector of Mexico's economy if it developed under BAU conditions. With this BAU scenario as the baseline, one can assess mitigation levers by calculating their abatement potential—how much would the implementation of each lever reduce annual emissions compared to BAU?

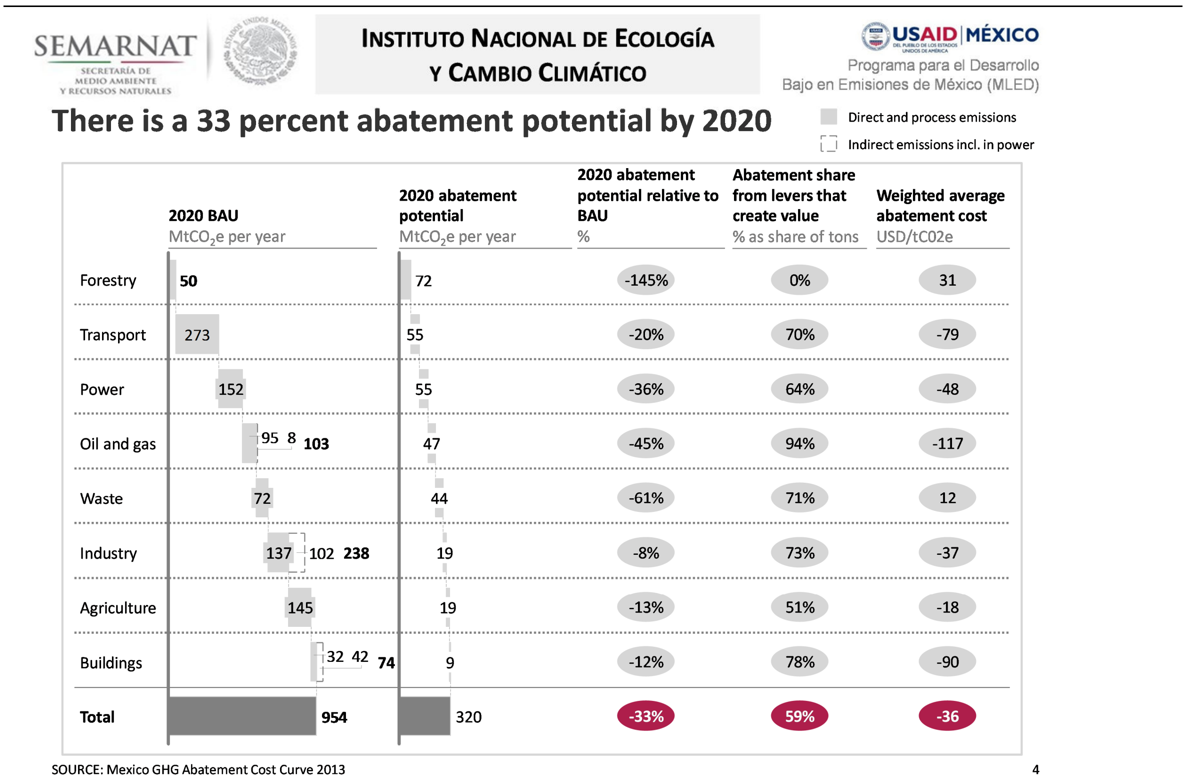
It is important to define the BAU scenario clearly. The BAU scenario is not a "frozen technology" scenario, but a theoretical scenario based on the following assumptions:

- The primary assumption of the BAU scenario is that Mexico acts in its economic self-interest and does not take additional action to avoid GHG emissions
- Investments in carbon abatement technology, such as wind parks, are included in the BAU scenario only if they were already under construction on **January 1, 2010**, or in the case of the power section, in an advanced stage of planning, e.g. included in POISE for the power sector
- The baseline is calculated based on industry production projections adjusted for an overall country GDP growth aspiration of 3.5% annual growth

The maximum technical potential for emission reductions is 33% of the baseline, and 59% comes at net financial benefits to the society

Full implementation of all emission reduction levers available to the maximum degree would decrease annual emissions in 2020 by ~ 33% compared to BAU. The maximum abatement potential in 2020 amounts to ~ 320 MtCO2e. If Mexico captured it fully, it would reduce emissions in 2020 from ~ 954 MtCO2e to ~ 634 MtCO2e and thereby reach its emission reduction target of 30%. Emissions would then be at ~ 90% level compared to 2010, while Mexico's GDP would have increased with 40%.

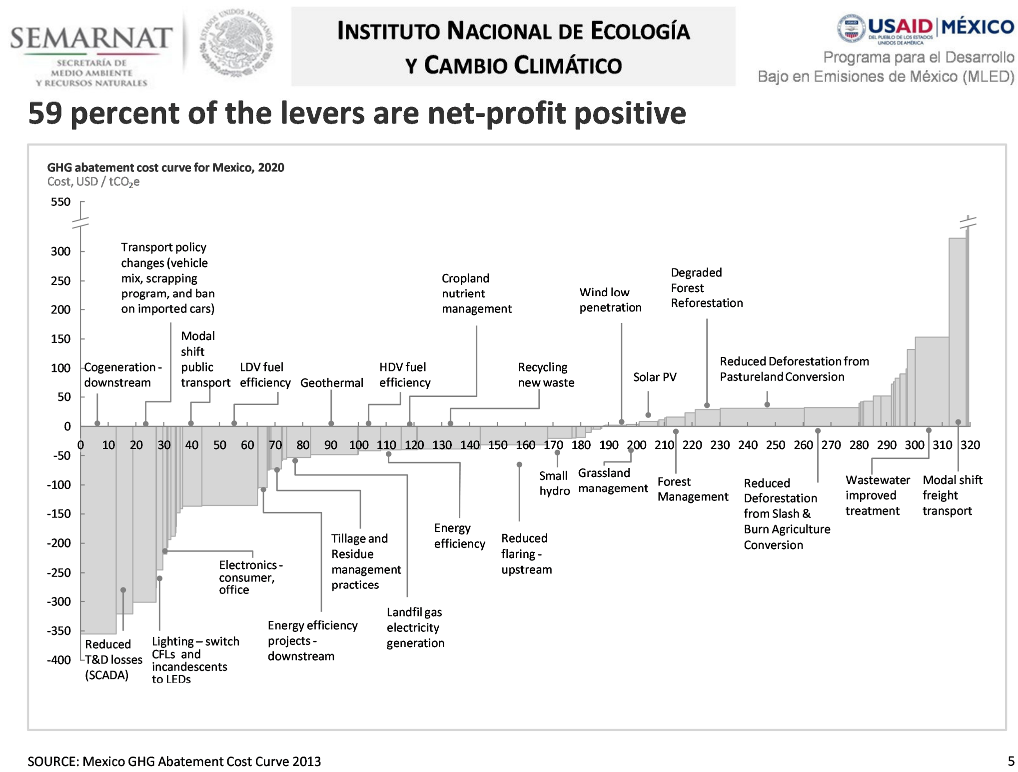
Exhibit 6



Certainly, some of the available levers are more difficult to grasp in practice than others because of high costs or natural barriers to implementation. However, Mexico has the opportunity not only to capture a large share of the maximum abatement potential but also realize net gains at the same time in order to boost economic and social development.

To guide such decision making, each available lever offers two chief characteristics—the number of tons of annual emissions that can be saved if the lever is fully implemented and the cost of implementing the lever per ton of emissions that it reduces. Mapping all levers on these two dimensions allows policy makers to compare the cost and benefit of each lever and, therefore, provides a great fact base for decision making. The mapping process results in a diagram called the abatement cost-curve as seen in the exhibit below.

Exhibit 7



Along with allowing the reader to compare and contrast all available emission reduction levers, the cost-curve yields several general conclusions about the maximum abatement potential in Mexico:

- 85% of the emission abatement potential in 2020 is concentrated in five sectors: forestry, transport, power, oil and gas, and waste
- 69% of the maximum abatement potential comes at zero or negative cost (represented by all columns extending downwards). The full implementation of these levers saves not only emissions but also money compared to the situation Mexico would reach by 2020 under the BAU scenario
- If all levers were implemented fully, the average abatement cost in 2020 would be a net financial benefit—a negative cost—of ~ USD 36 per ton of reduced emissions. This means that implementing all levers fully would actually save the Mexican economy USD 11.5 billion per year by 2020 compared to the BAU scenario
- Implementing ten measures with the largest abatement potential would capture 55% of the total abatement potential by 2020
- A scenario analysis on prices of gas, gasoline, electricity, and interest rates shows that few but important levers, such as wind and solar PV, are sensitive to changes in a way that they change from cost negative to cost positive or vice versa

85% of the emission abatement potential in 2020 is concentrated in five sectors: forestry, transport, power, oil and gas, and waste. These are the key sectors of the climate agenda for Mexico, offering great impact in terms of carbon abatement as well as economic and social development.

- The forestry sector holds almost 25% of the maximum abatement potential. Current estimates suggest that Mexico could transform the sector into a net carbon sink. While acknowledging significant data uncertainties, estimations of current net emissions add up to ~ 50 MtCO2e and are expected to stay constant until 2020 under BAU assumptions. By implementing all abatement measures, Mexico could turn the forestry sector into a carbon sink that sequesters up to ~ 22 MtCO2e by 2020 at an estimated average cost of ~ USD 31/tCO2e without taking into account the significant co-benefits that exist in the sector. This maximum abatement potential is mainly driven by reducing deforestation (70%) and 30% of the potential comes from increasing afforestation and reforestation (A/R)

- The transport sector has the potential to reduce GHG emissions from burning fossil fuels by 20% compared to the BAU scenario in 2020, equaling a total abatement potential of 55 MtCO2e in 2020. 54% of the abatement potential (30 MtCO2e) is derived from fuel efficiency measures primarily targeting LDVs. 24% of abatement (13 MtCO2e) is driven by modal shifts to public and freight transport. 15% of abatement (8 MtCO2e) comprises policy measures, i.e., vehicle mix, scrapping program, and ban of imported cars. Around 70% of the transport levers are net-profit-positive
- The power sector holds around 17% of Mexico's maximum abatement potential. Annual emissions in the sector could be reduced by 36% compared to the BAU scenario by 2020, dropping from an annual 152 MtCO2e to only 97 MtCO2e. 31% of abatement (17 MtCO2e) is derived from geothermal power generation. 16% of abatement (9 MtCO2e) comprises small hydro generation. Remaining abatement contribution (29 MtC02e) is from other renewable sources, e.g., wind, reduction of transmission losses, and shift within fossil fuels. Around 70% of the power levers are net-profit-positive. Net-profit-negative levers such as wind and solar PV have seen a severe decrease in cost versus traditional technologies, but are with current projections not yet fully cost competitive
- The oil and gas and waste sectors can, in combination, contribute almost 30% of the abatement potential. The largest abatement opportunities are a reduction of gas flaring; recycling new waste; cogeneration in Pemex's refineries, and wastewater improved treatment. More than 90% of oil and gas abatement levers and 70% of waste levers come at an overall financial gain to the society

The environmental benefits identified could have a positive impact on the Mexican economy. Many of the abatement measures examined are net-profit-positive to the economy—i.e., they are beneficial to the economy as a whole. An example of a net-profit-positive measure is fuel efficiency improvements in LDVs, for which the increased up-front cost of the technology improvements is more than compensated for by the savings in fuel consumption costs.

On average, the abatement potential comes at a net-profit-positive gain of USD 36 for every ton of CO2e that gets abated compared to the BAU scenario, with 59% abatement potential achievable at net-profit-positive gain. The remaining 31% of abatement potential comes at a cost to Mexico compared to the BAU scenario. The total net cost to the economy of implementing all technical measures is overall positive to the economy in 2020. Hence, should all measures be implemented, savings from the net-profit-positive abatement measures would cancel out the costs of the others.

The two main factors preventing the implementation of the net-profit-positive measures are the financing hurdles and rapid payback requirements. The up-front investment needed, particularly in the power and transportation sectors, can be significant, and most consumers tend to want a return on their investment within two years. There are also agency issues. In many cases, the consumer or company reaping the benefit of lower energy bills is not the one making the up-front investment. Construction companies, for example, have limited incentives to insulate homes beyond the level required in building codes, since it is home owners and tenants who will enjoy lower energy costs.

The ten levers with the highest abatement potential are shown below. Details of all levers appear in the appendix of this report.

1. Reduced deforestation from pastureland conversion (30 MtCO2e)
2. Reduced flaring (24 MtC02e)
3. Recycling new waste (23 MtC02e)
4. LDV fuel efficiency (20 MtCO2e)
5. Reduced deforestation from slash & burn agriculture conversion (20 MtC02e)
6. Geothermal (17 MtC02e)
7. Cogeneration—downstream in oil and gas (13 MtC02e)
8. Wastewater—improved treatment (12 MtC02e)

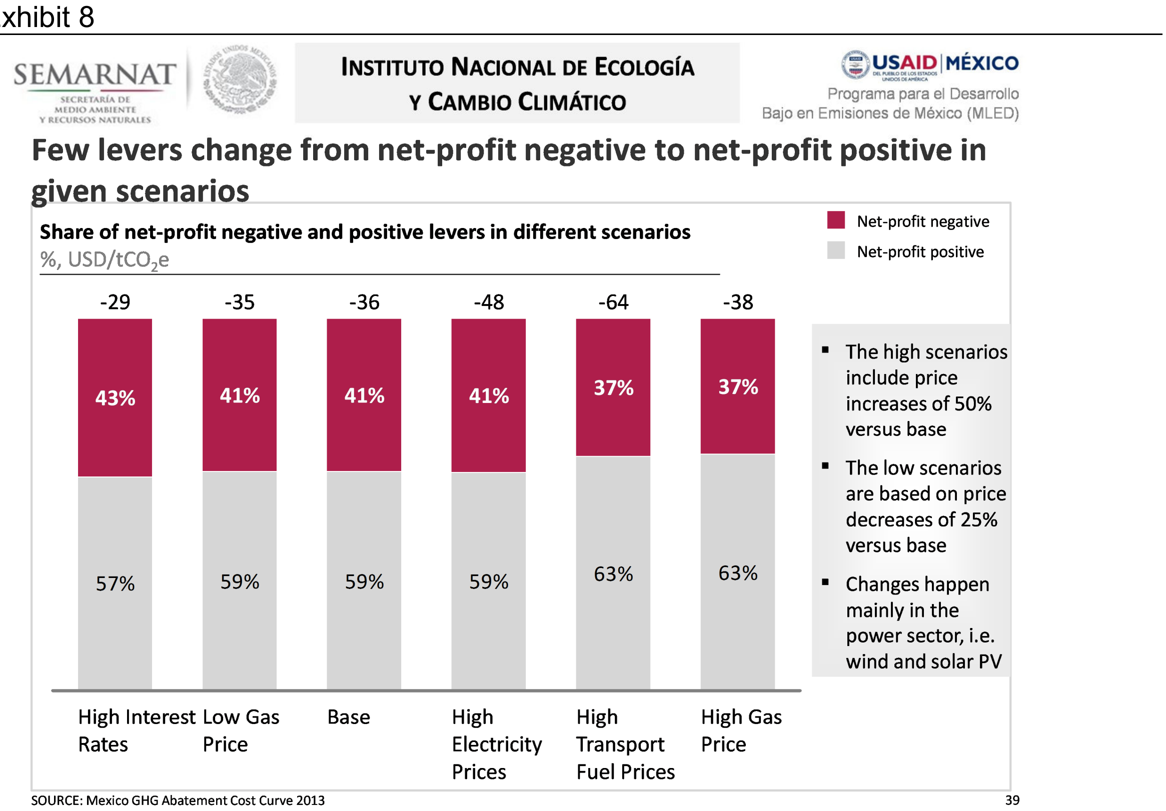
9. Degraded forest reforestation (9 MtCO2e)
10. Small hydro (9 MtC02e)

Caveats regarding the maximum abatement potential

- The maximum abatement potential presented here does not represent actual targets but rather the maximum potential to reduce annual GHG emissions by 2020, based on plausible but ambitious government policy and adoption rates
- The results are based on the expertise of the technical working groups in INECC and local data where available, but significant data improvement opportunities remain, especially concerning forestry and the renewable energy potential
- The economic impact has been estimated on a stand-alone-project basis without taking second-order effects or co-benefits into account

A sensitivity analysis, see below exhibit, shows that few levers change from being net-profit-negative to net-profit-positive in different price scenarios. However, the sensitivity analysis shows great difference in the average cost of the various technologies. For example, in the case of high transport fuel prices (50% higher than 2020 projection), the overall average abatement cost of one ton of C02e will decrease to USD -64/ton from USD -36/ton in our base case. This also means that the average abatement lever gets almost twice as attractive and that the society would gain USD 64 per ton of CO2e abated. In the case of higher interest rates (of 7% instead of the base case of 4%) the average cost of abatement is still negative (hence a gain to the society). The total gain is USD 29/ton of C02e abated versus the USD 36 per ton in the base case.

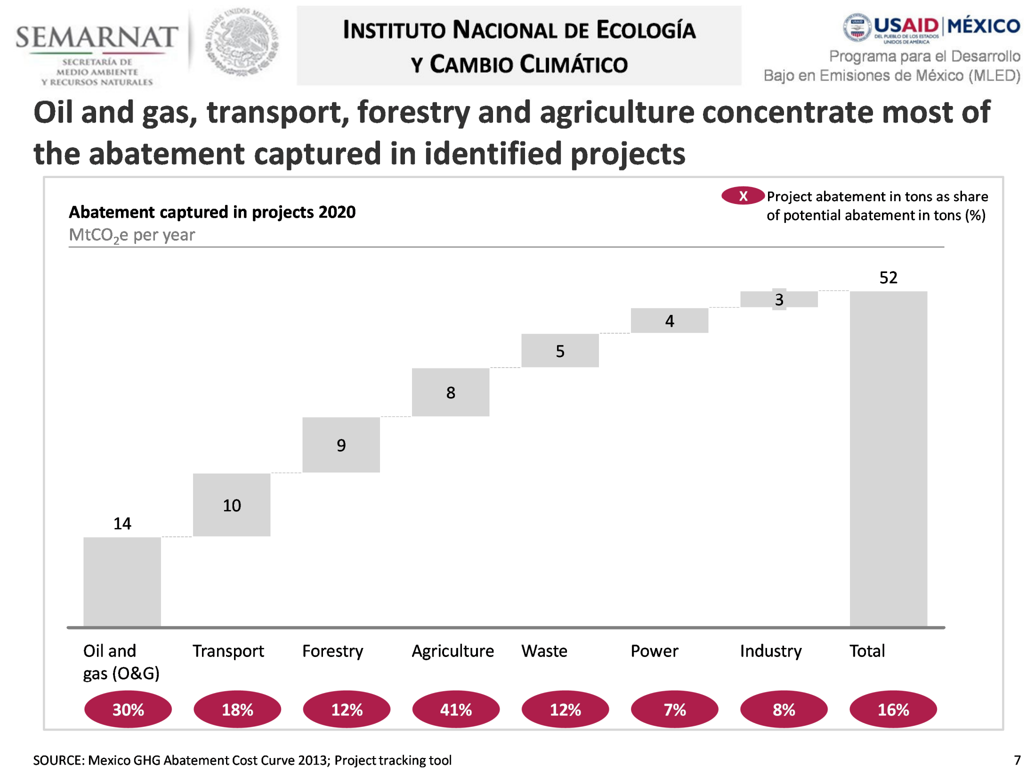
Exhibit 8



52 MtCO2e, or 16% of the abatement potential by 2020, is captured in emission mitigation projects

We developed a project portfolio database during the project, based on publicly available information from sources, e.g., CONAFOR, FONADIN, GDF, PECC, SCT, POISE, CRE, PEMEX, SEMARNAT, CDM projects, SAGARPA. The largest potential is captured in the oil and gas and transport sectors, which have captured respectively 30% and 18% of their total abatement potential, as seen in the following exhibit.

Exhibit 9



However, only 28% of the net-profit-positive potential is currently captured in projects, indicating a large opportunity to accelerate the agenda. The largest untapped opportunities are reduction of deforestation from pastureland and slash & burn agriculture conversion, recycling of new waste, and geothermal.

Conclusions and Recommendations

Conclusions

This study scope was to update the emissions baseline and the abatement cost-curve and develop a project portfolio with a focus on 2020, but with a total timeline up to 2030. The project developed five scenarios to change the abatement costs and assessed a total of 129 abatement levers relevant to Mexico. The project wanted to test two central questions:

- Can Mexico deliver on its 30% emission reduction target set in COP15 in Copenhagen?
- How much of the emission reduction target is captured in current or planned projects?

The study shows that the target of 30% emission reduction is technically feasible, as the total identified abatement potential of 320 MtC02e equals 33% of the baseline 2020 emissions. 59% of this abatement potential result in a net profit gain to the society and the overall average is at a net gain of 36 USD/ton, indicating an overall feasibility of implementing all levers. However, due to agency problems and other barriers it will be a large challenge in reality for Mexico to achieve the target and capture the full abatement potential.

Currently only 52 MtC02e out of the 320 MtC02e potential is captured in projects that we have been able to identify. As such the overall capture rate is less than 20%. This allows for significant untapped potential for example in some of the largest levers such as reduction in deforestation from pastureland conversion and slash & burn agriculture, geothermal and small hydro. The project has highlighted the gaps between the theoretical potential and the potential captured in projects, which could serve as input to the upcoming revision of the PECC. The results can be seen in the appendix.

Today, INECC has the cost-curve models and project tracker tool and will be able to update the analysis on an ongoing basis as new and improved information arises.

Recommendations

Continue to update data input as more information gets available

While the project did a thorough assessment of latest Mexico specific information on the potential of technologies as well as the cost, more information arises on a constant basis, which would serve as great input to the cost-curves. Further, the project tracking tool needs a continuous update and could further be improved by a greater integration of industry specific initiatives. As new information gets available, certain assumptions of possible implementation rates of technologies should also be updated.

As such the cost-curves and project tracking tools could benefit from annual revisions and updates.

Continue with trainings and skill-building in INECC

While the project dedicated a significant share of its resources to build skills within INECC the share depth and details of the cost-curves can justify more training than what was possible within the scope of the 8 weeks.

Improve the process to develop the cost-curves

We state above that the cost-curves could benefit from annual revisions and updates. To be able to achieve this, INECC could have quarterly progress reviews, where the working teams present the potential updates in their sector. This would allow for continuous improvement and ensure that the capabilities to update the cost-curves continuously get improved. Further, we suggest an inclusive process across Government institutions. The cost-curves benefit greatly from the input of many institutions not only to improve the input going into the models, but also the ownership of the conclusions and the identified opportunities for abatement across sectors.

Implement Short-Lived Climate Forcers

During the project we had a few sessions on the impact of short-lived climate forcers and how to potentially incorporate the impact in a cost-curve. While the science is still relative young on this topic, we came to a joint conclusion that it could be beneficial to include these in future updates of cost-curves in a common CO2 equivalent denominator and with USD/ton abatement cost.

Incorporate quantitative analysis of co-benefits

We assessed co-benefits in a qualitative way for all projects that are currently in place in Mexico, see Appendix on project templates. However, for future updates of the cost-curves it would be highly beneficial to be able to show the co-benefits of technological levers that may not be net profit positive today. For example the co-benefits of keeping the rich biodiversity of the Mexican forests, or the improved health benefits in cities of reducing the dependency on traditional fuels.

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Appendix One: Baseline approach

Included in this appendix is an explanation of the structure behind the baseline calculations for each sector.

Agriculture

Agriculture emits non-CO2 emissions through several key processes for example: agricultural soil practices; livestock enteric fermentation and livestock manure management. Agricultural soil practices are production of N2O in soils through the microbial process of (de)nitrification. Anthropogenic sources of nitrogen include various cropping practices and livestock waste disposal on the fields. Livestock enteric fermentation is a process whereby microbes in an animal's digestive system ferment food. Methane is produced as a byproduct and is exhaled by the animal. The below exhibit shows the various elements of the baseline calculation, which follows IPCC guidelines, as well as the results.

Exhibit 10

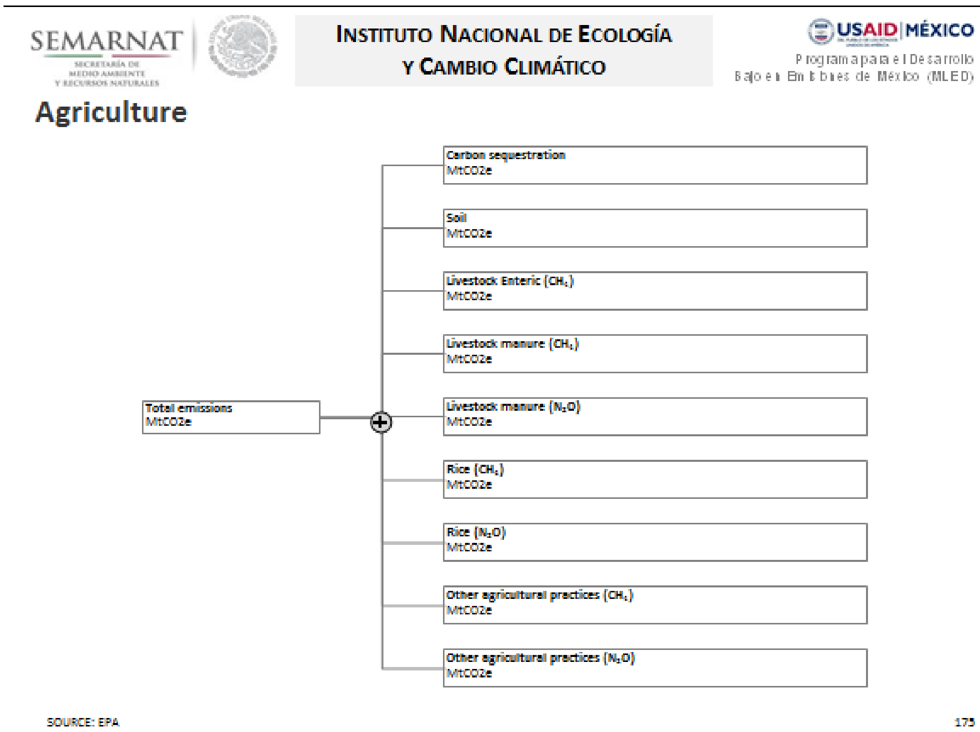
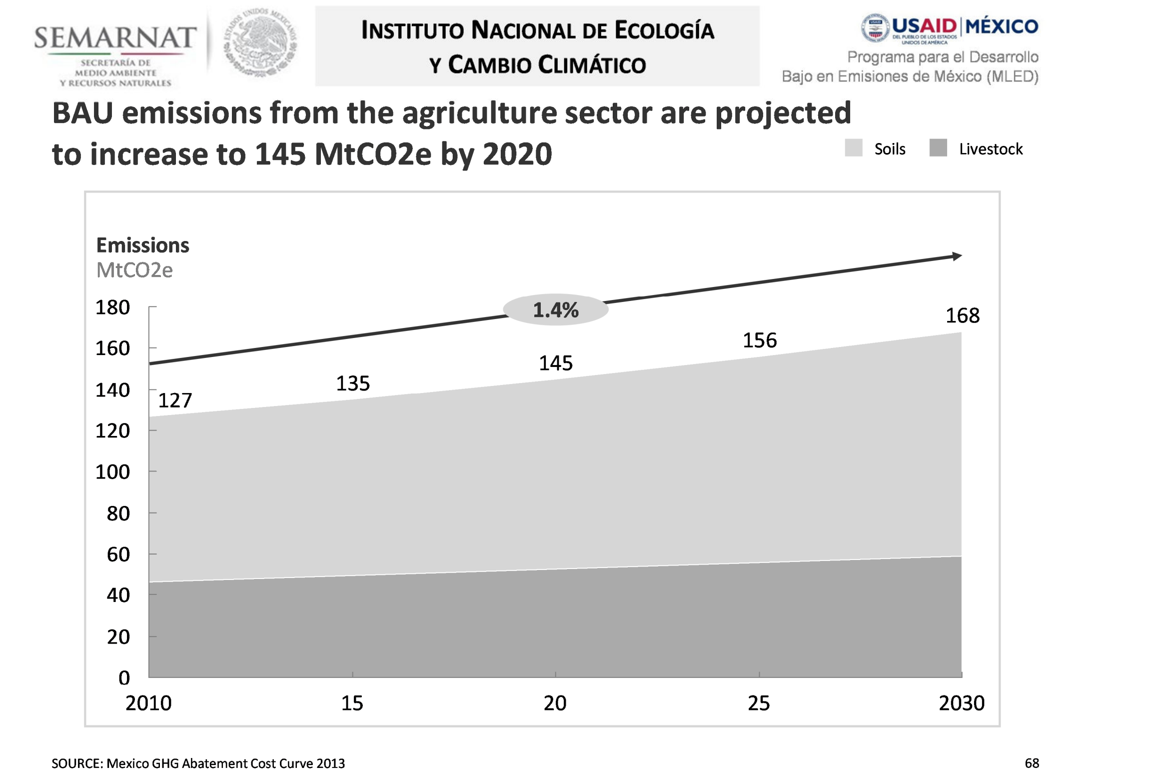


Exhibit 11



Forestry

The baseline emissions from the forestry sector are calculated based on emissions from deforestation and effect of carbon sequestration from afforestation and reforestation. A vast majority of the deforestation emissions is caused by conversion of forest to pastureland or to slash & burn agriculture land. It is assumed that the emission level will stay constant at 50 MtCO2 per annum in a BAU scenario.

Exhibit 12

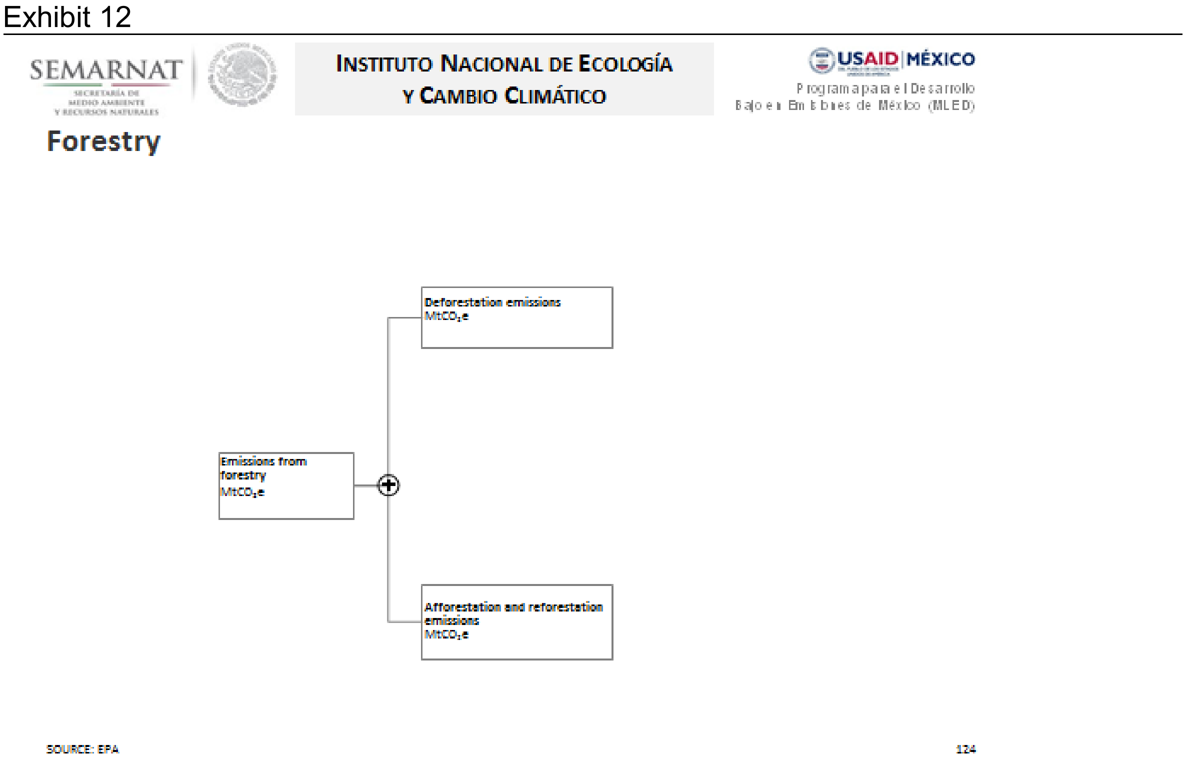
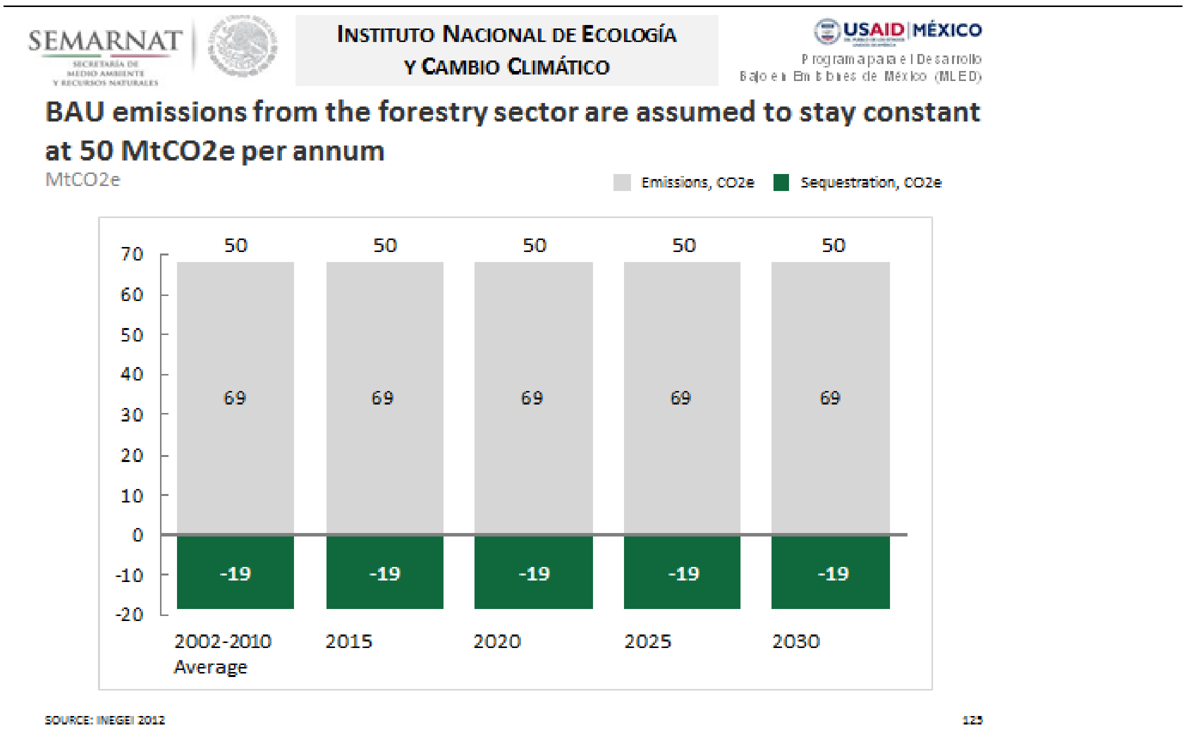


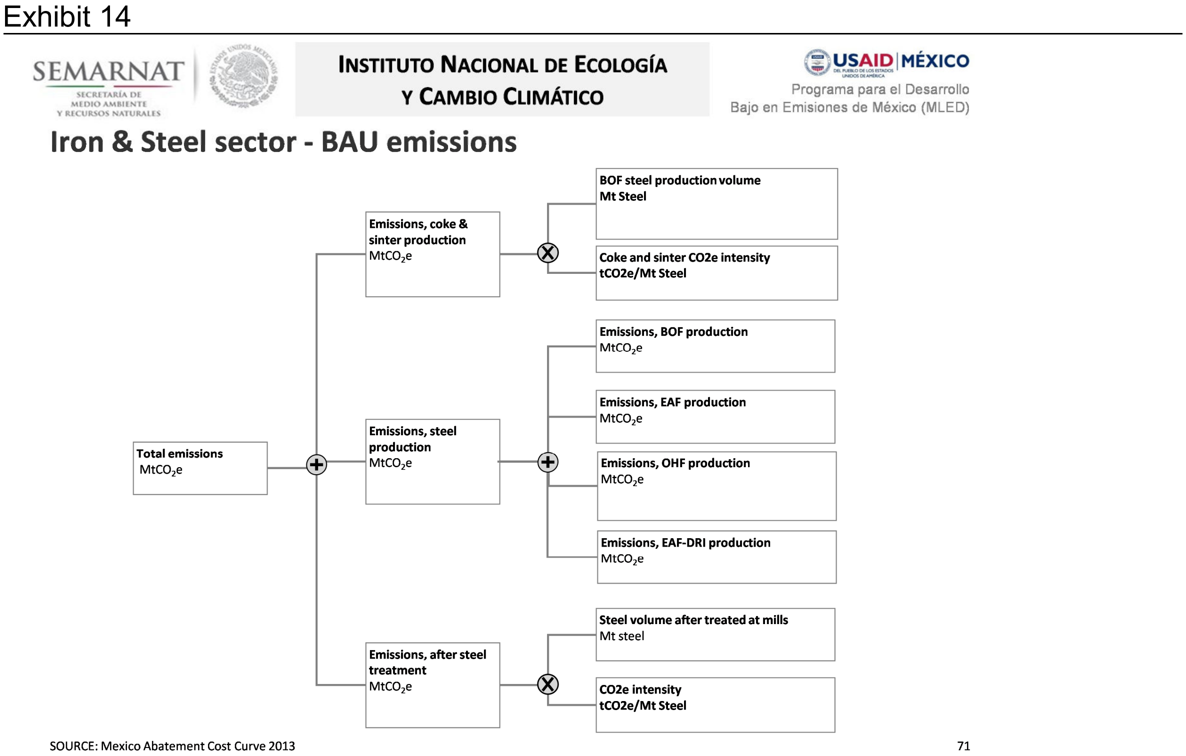
Exhibit 13



Industry

The industry sector is comprised of four sectors namely—Iron and Steel, Chemicals, Cement and Other Industry. There are three types of GHG emissions in the industrial sector—(a) Process Emissions—these are released from processes in the cement and chemicals industries (b) Direct Emissions from fuel combustion - and (c) Indirect Emissions from electricity consumption. Sector emissions totaled 170 MtCO2e in 2010 (23% of total emissions). Under a BAU scenario, emissions are projected to grow at 3.4% annually reaching 238MtCO2e by 2020. Iron and Steel is the fastest growing sector at 5.4% annually. For Iron and Steel the major part of the emissions comes from coke & sinter production, steel production and after steel treatment.

Exhibit 14



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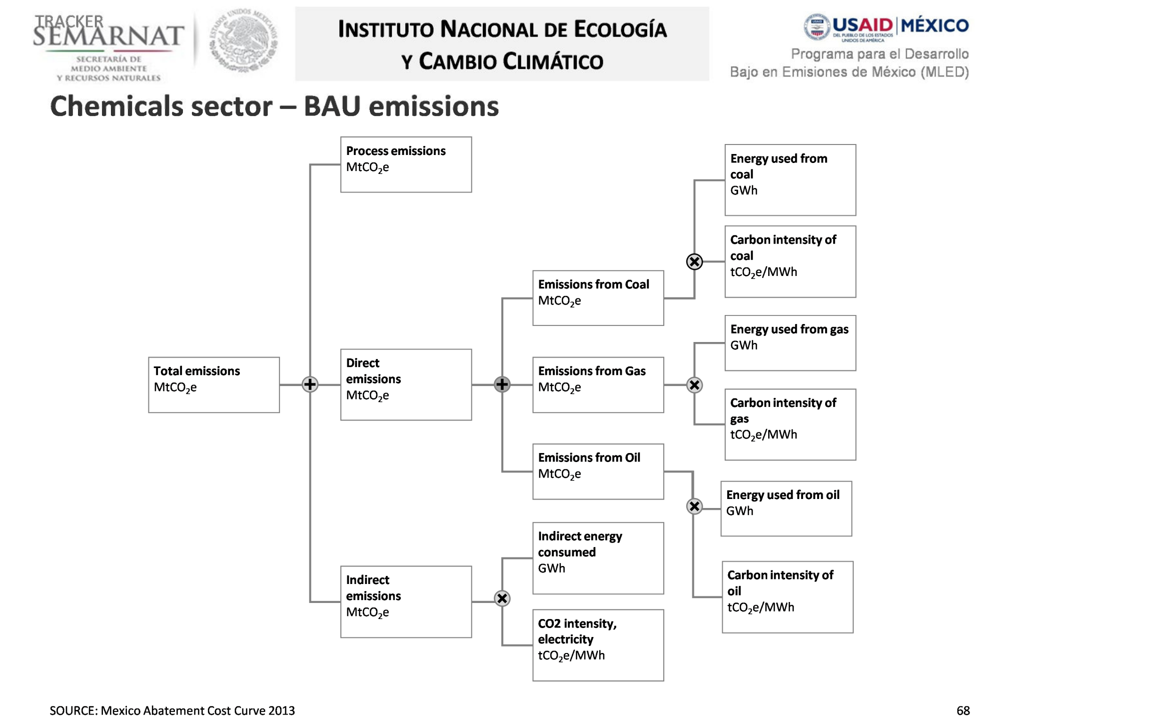


Exhibit 16

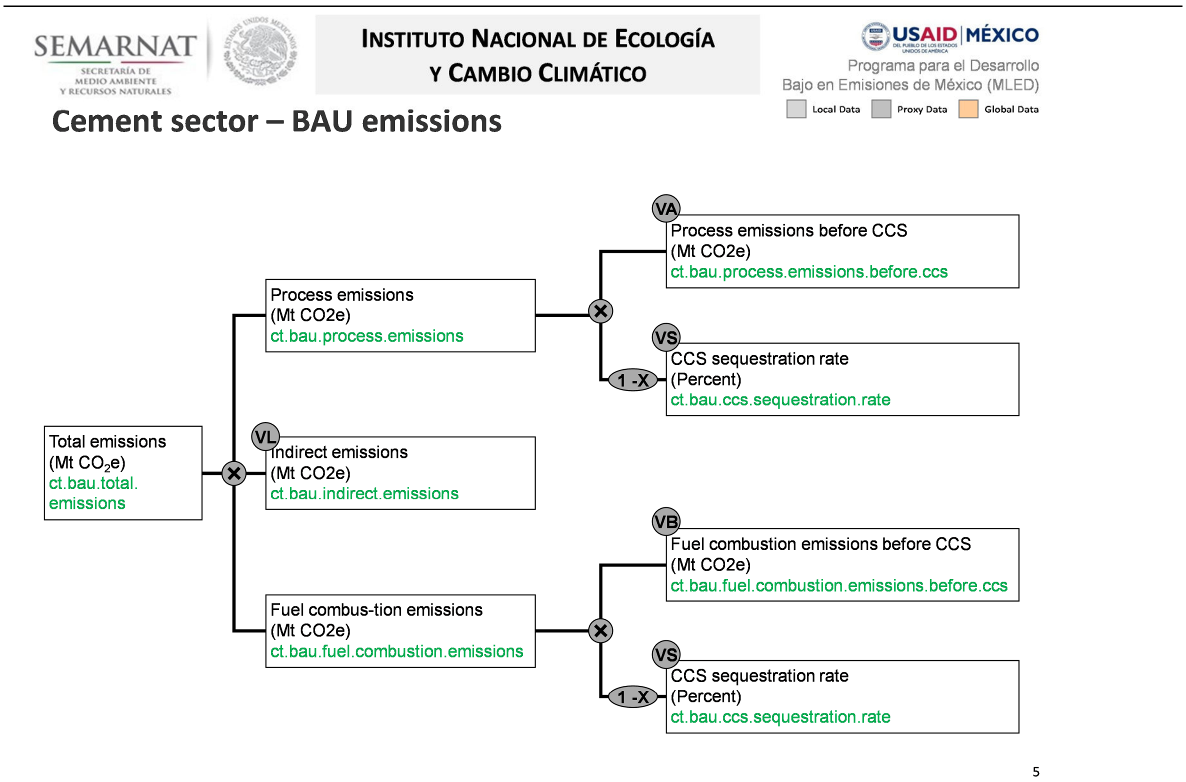
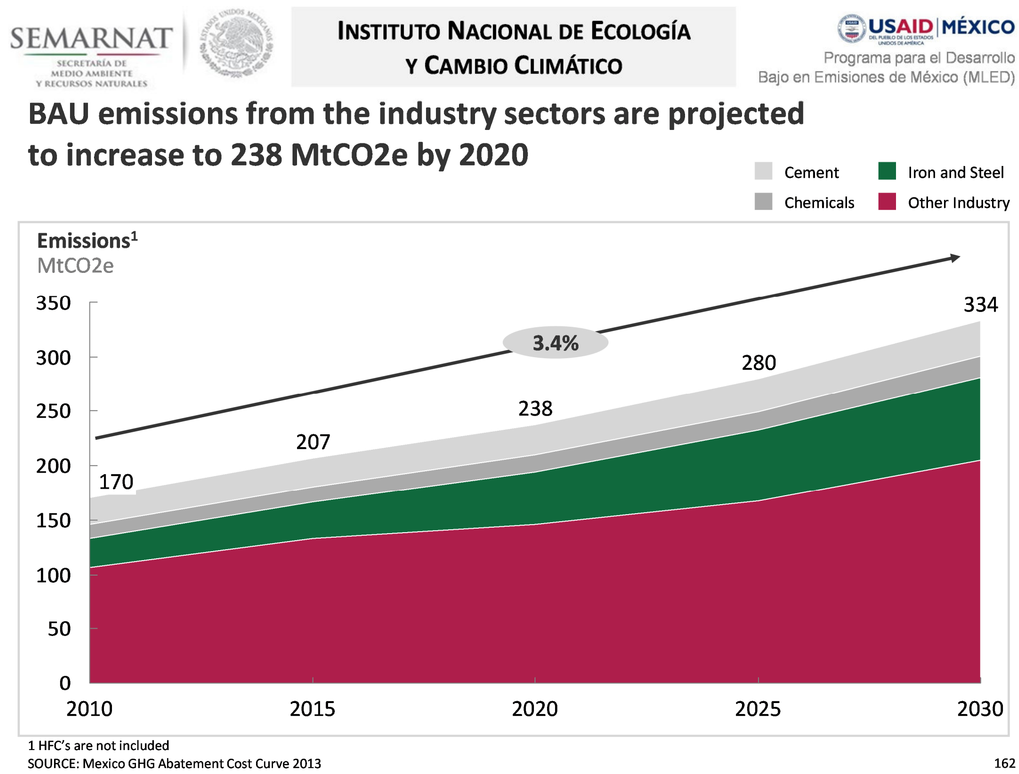


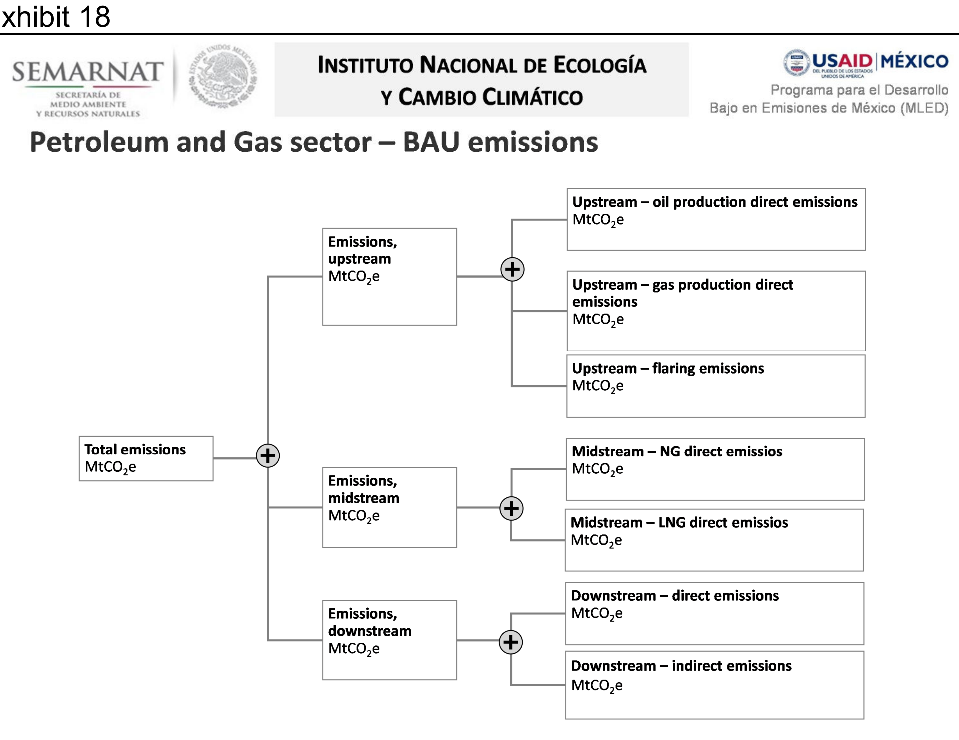
Exhibit 17



Oil and gas

Oil and Gas is composed of three distinct sectors—(a) Upstream production and processing of gas, conventional and non-conventional oil (b) Midstream transport of gas both through fixed piping networks as well as by LNG tankers and (c) Downstream refining of crude oil into refined fuel products. The Oil and Gas sector emissions totaled 100MtCO2e in 2010 (14% of total emissions). Under a BAU scenario emissions are projected to grow moderately reaching 103 MTCO2e by 2020 (11% share of total emissions). Gas flaring and combustion are the largest drivers of the emissions.

Exhibit 18



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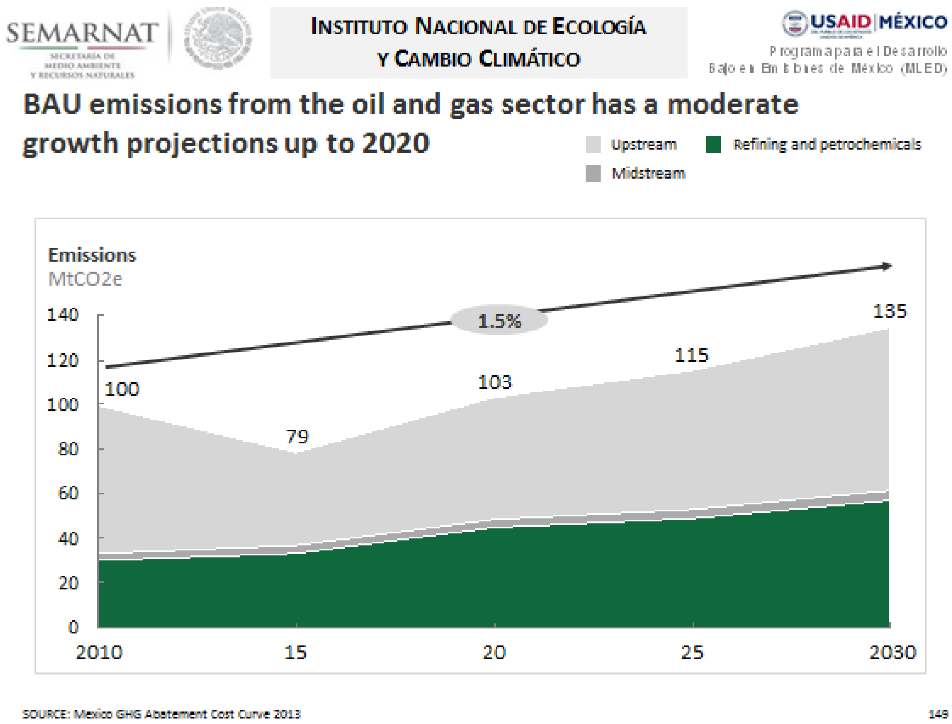


Power

The power sector can be split into conventional fossil technologies (coal, gas and oil), nuclear and renewable energy sources (e.g. wind, solar and biomass) and CCS technologies. The sector emissions totaled 122 MtCO2e in 2010 (17% of total emissions). Under a BAU scenario emissions are projected to grow at 2.4% annually reaching 152 MtCO2e by 2020 (15% of total emissions). The baseline mix is shifting from oil towards gas based on POISE 2010; hence the baseline is relative carbon efficient.

Exhibit 20

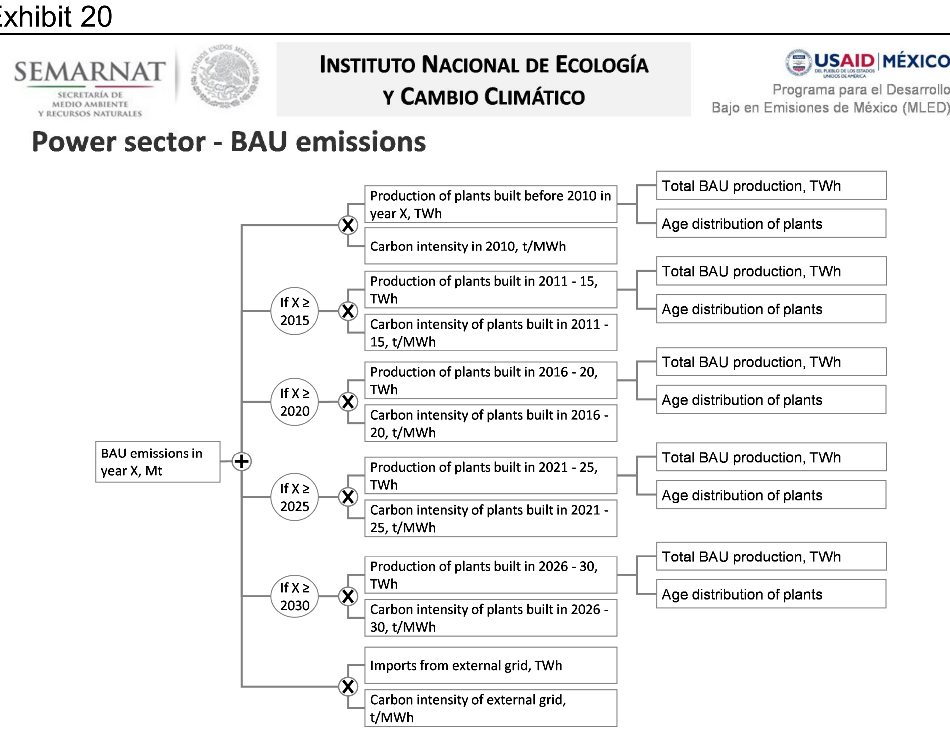
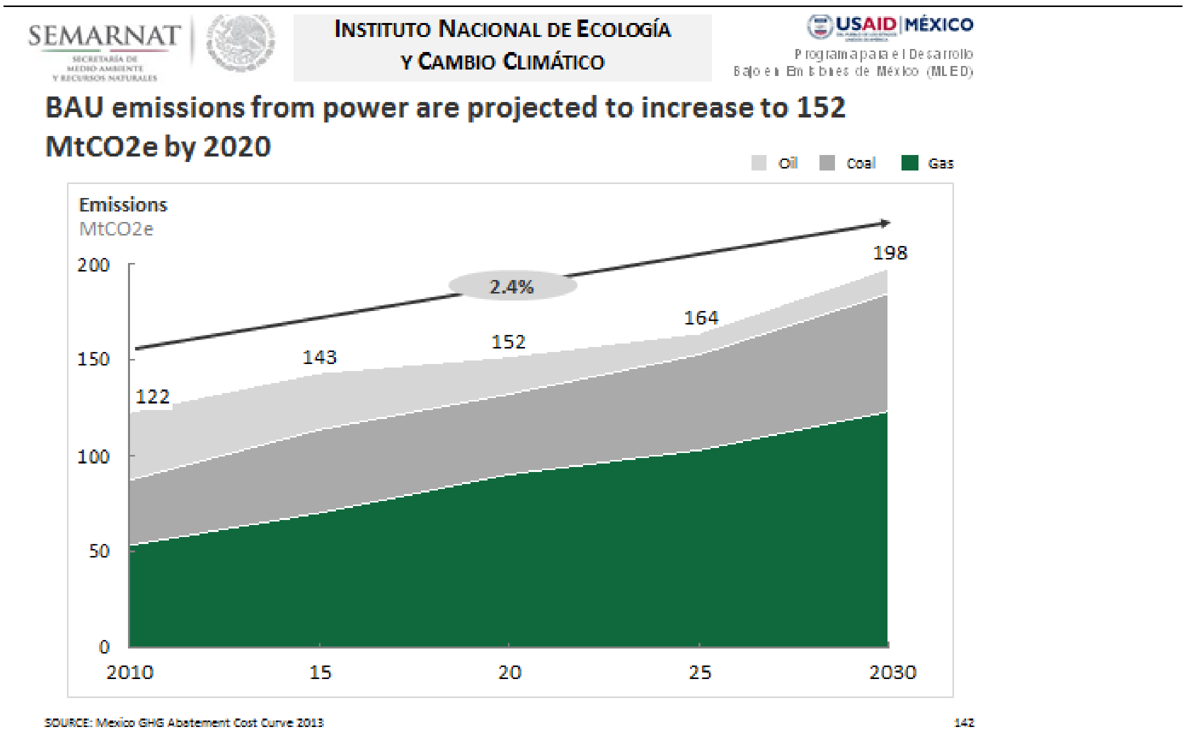


Exhibit 21



Transport

The road transport sector can be further segmented into light, medium, and heavy duty vehicles. Light duty vehicles are equivalent to passenger cars, medium-duty vehicles are delivery trucks < 16 t of weight and SUVs, and heavy-duty vehicles are long-haul trucks>16t. In addition different vehicle types run on different fuel types which can either be of fossil origin or produced from biomass. Especially in the light duty segment vehicles/emitters are largely privately owned; in the medium and heavy-duty segment, emitters are usually owned by commercial enterprises operating in the freight forwarding and delivery business.

Exhibit 22

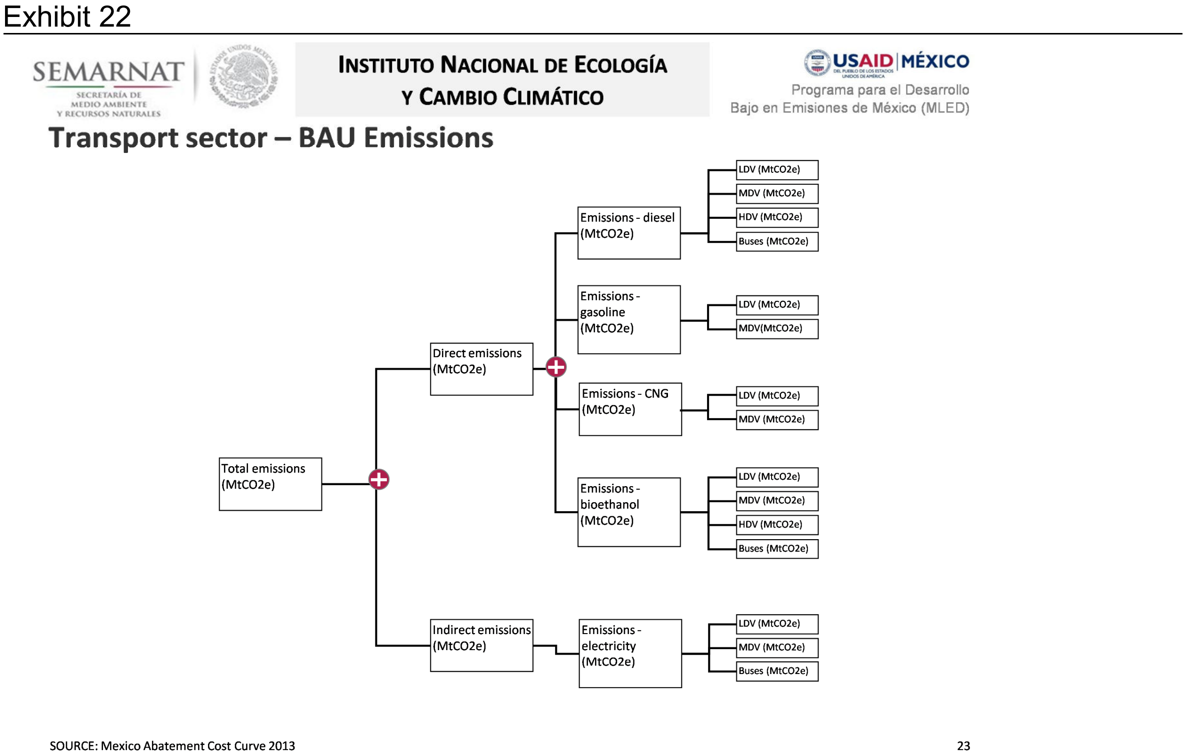
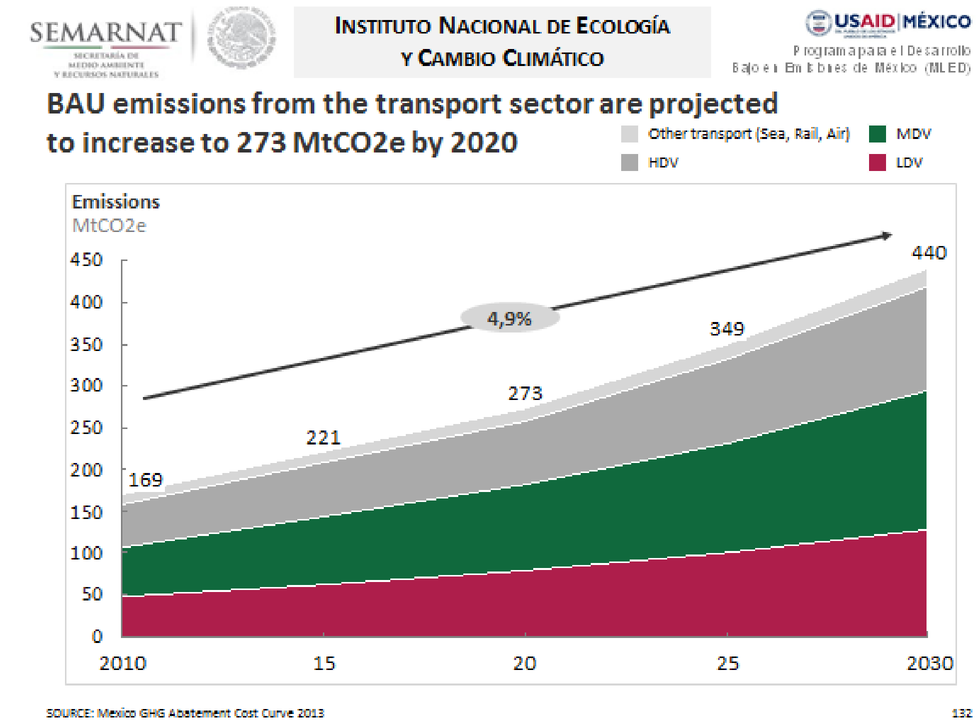


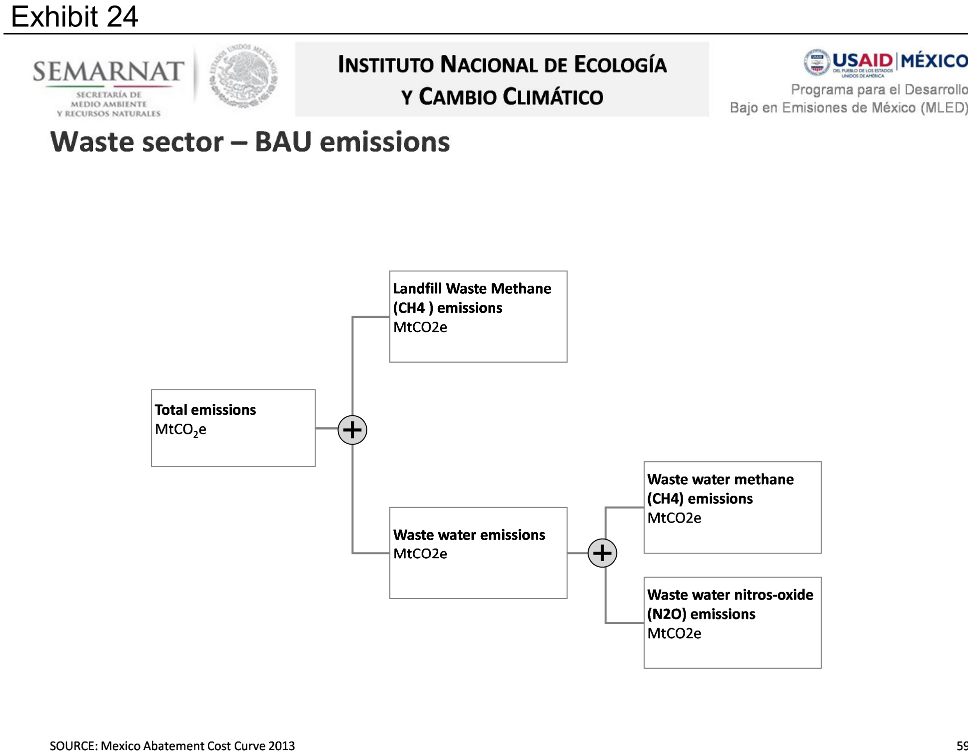
Exhibit 23



Waste

Sector emissions totaled 56 MtCO2e in 2010 (6% of total emissions). Under a BAU scenario, emissions are projected to grow at 5.2% annually reaching 72 MtCO2e by 2020 (8% share of total emissions). Increasing waste generation per capita as a result of increased wealth and urbanization drives emissions.

Exhibit 24



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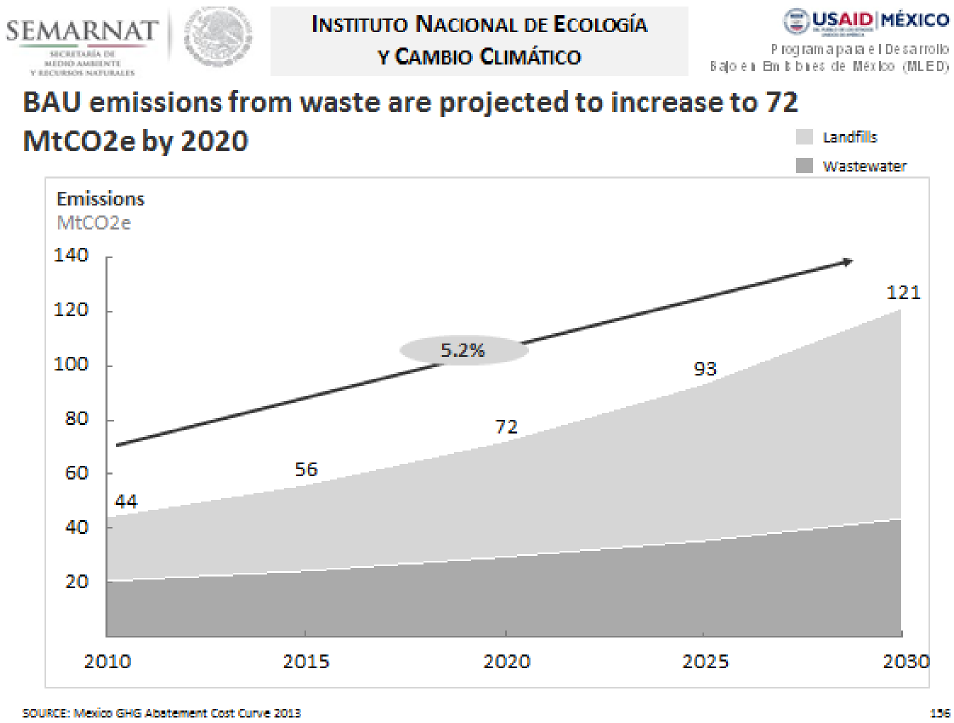


Appendix Two: Cost-curve structure and assumptions

In the following we describe the three most important levers for each of the sectors, measured by abatement impact and cost, as well as show the overall results for each sector.

Agriculture

Tillage and residue management practices

Soil carbon sequestration: Advances in weed control methods and farm machinery now allow many crops to be grown with minimal tillage (reduced tillage) or without tillage (no-till). These practices are now increasingly used throughout the world. Since soil disturbance tends to stimulate soil carbon losses through enhanced decomposition and erosion, reduced- or no-till agriculture often results in soil carbon gain, but not always.

N20 emissions reductions: Adopting reduced- or no-till may also affect N2O, emissions but the net effects are inconsistent and not well-quantified globally. The effect of reduced tillage on N2O emissions may depend on soil and climatic conditions. In some areas, reduced tillage promotes N2O emissions, while elsewhere it may reduce emissions or have no measurable influence.

Residue management: Systems that retain crop residues also tend to increase soil carbon because these residues are the precursors for soil organic matter, the main carbon store in soil. Avoiding the burning of residues (e.g., mechanizing sugarcane harvesting), eliminating the need for pre-harvest burning also avoids emissions of aerosols and GHGs generated from fire, although CO2 emissions from fuel use may increase

Cropland nutrient management

Nitrogen applied in fertilizers, manures, bio solids, and other N sources is not always used efficiently by crops. The surplus N is particularly susceptible to emission of N2O. Consequently, improving N use efficiency can reduce N2O emissions and indirectly reduce GHG emissions from N fertilizer manufacture. By reducing leaching and volatile losses, improved efficiency of N use can also reduce off-site N2O emissions. Examples of practices that improve N use efficiency include:

- Adjusting application rates based on precise estimation of crop needs (e.g., precision farming);

- Using slow- or controlled-release fertilizer forms or nitrification inhibitors (which slow the microbial processes leading to N2O formation);
- Applying N when least susceptible to loss, often just prior to plant uptake (improved timing);
- Placing the N more precisely into the soil to make it more accessible to crops roots;
- or avoiding N applications in excess of immediate plant requirements

Grassland management

Grazing lands occupy much larger areas than croplands and are usually managed less intensively. Following potential practices exist:

- **Grazing intensity**: The intensity and timing of grazing can influence the removal, growth, carbon allocation, and flora of grasslands, thereby affecting the amount of carbon accrual in soils. The effects are inconsistent, however, owing to the many types of grazing practices employed and the diversity of plant species, soils, and climates involved
- **Increased productivity** (excluding fertilization): As for croplands, carbon storage in grazing lands can be improved by a variety of measures that promote productivity
- **Irrigating grasslands**, similarly, can promote soil carbon gains. The net effect of this practice, however, depends also on emissions from energy use and other activities on the irrigated land
- **Fire management**: On-site biomass burning contributes to climate change in several ways (see IPCC chapter for details). Reducing the frequency or intensity of fires typically leads to increased tree and shrub cover, resulting in a CO2 sink in soil and biomass (saturation over 20-50 years, whereas avoided CH4 and N2O emissions continue as long as fires are suppressed). Mitigation actions involve reducing the frequency or extent of fires through more effective fire suppression; reducing the fuel load by vegetation management; and burning at a time of year when less CH4 and N2O are emitted
- **Species introduction**: Introducing grass species with higher productivity, or carbon allocation to deeper roots, has been shown to increase soil carbon. For example, establishing deep-rooted grasses in savannahs has been reported to yield very high rates of carbon accrual, although the applicability of these results has not been widely confirmed. In the Brazilian Savannah Brachiaria grasses are being adopted. Introducing legumes into grazing lands can promote soil carbon storage through enhanced productivity from the associated N inputs, N2 fixation displaces applied N fertilizer N.

The key assumptions and results are shown in the below exhibits:

Exhibit 26

SEMARNAT SECRETARÍA DE MEDIO AMBIENTE Y RECURSOS NATURALES | INSTITUTO NACIONAL DE ECOLOGÍA Y CAMBIO CLIMÁTICO | USAID MÉXICO Programa para el Desarrollo Bajo en Emisiones de México (MLED)

Key assumptions

Lever	Key volume assumptions	Key cost assumptions
Cropland nutrient management	• Cropland area, moist warm, 9.2 mha • Cropland area, dry warm, 13.8 mha • Abatement potential per ha, moist warm: 0.55 tCO2e/ha • Abatement potential per ha, dry warm: 0.26 tCO2e/ha • Cropland area nutrient management BAU, 2020: 10% • Cropland area nutrient management RC, 2020: 65%	• Cropland nutrient management cost 5 USD/ha/y *(RSTB)*
Grassland management	• Grassland area, moist warm, 12.4 mha • Grassland area, dry warm, 18.6 mha • Abatement potential per ha, moist warm: 0.81 tCO2e/ha • Abatement potential per ha, dry warm: 0.11 tCO2e/ha • Grassland area management BAU, 2020: 5% • Grassland area management RC, 2020: 40%	• Grassland management cost 5 USD/ha/y *(RSTB)*
Tillage and residue management	• Abatement potential per ha, moist warm: 0.70 tCO2e/ha • Abatement potential per ha, dry warm: 0.33 tCO2e/ha • Shared reduced BAU, 2020: 4% • Share reduced RC, 2020: 45%	• Tillage and residue management cost 0.02 USD/ha/y *(RSTB)*

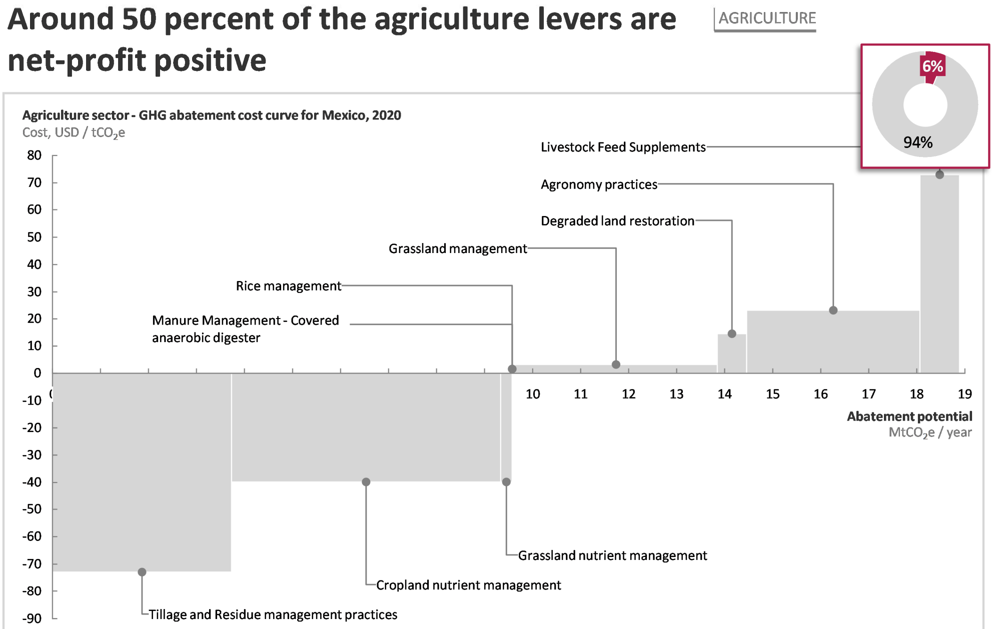
SOURCE: Mexico GHG Abatement Cost Curve 2013 73

Exhibit 27

SEMARNAT SECRETARÍA DE MEDIO AMBIENTE Y RECURSOS NATURALES | INSTITUTO NACIONAL DE ECOLOGÍA Y CAMBIO CLIMÁTICO | USAID MÉXICO Programa para el Desarrollo Bajo en Emisiones de México (MLED)

Around 50 percent of the agriculture levers are net-profit positive

AGRICULTURE



SOURCE: Mexico GHG Abatement Cost Curve 2013 70

Forestry

Overall abatement potential is in the range of 72 MtCO2e, 145% of 2020 BAU, meaning that the forest sector can become a net sink. 69% of abatement (50 MtCO2e) is derived from reduction in deforestation from pastureland conversion and smallholder agriculture. The remaining part is from reforestation and afforestation activities, where degraded forest reforestation is the largest lever with 13% of total abatement (9 MtCO2e). All abatement levers come at a net cost to the society.

Reduced deforestation from pastureland conversion

This lever is achieved through compensation of landholders for the lost revenue from one time timber extraction and future cash flows from ranching.

Reduced deforestation from slash & burn agriculture conversion

This lever is also achieved through compensation payments and income support to the rural forest people to prevent agriculture expansion into forested areas.

Degraded forest reforestation

This lever regenerates forests, which have been deforested or degraded historically. The strategy is to reforest areas and allow the forest to regenerate or to use sustainable silviculture to manage the forest land better.

The key assumptions and results are shown below:

Exhibit 28

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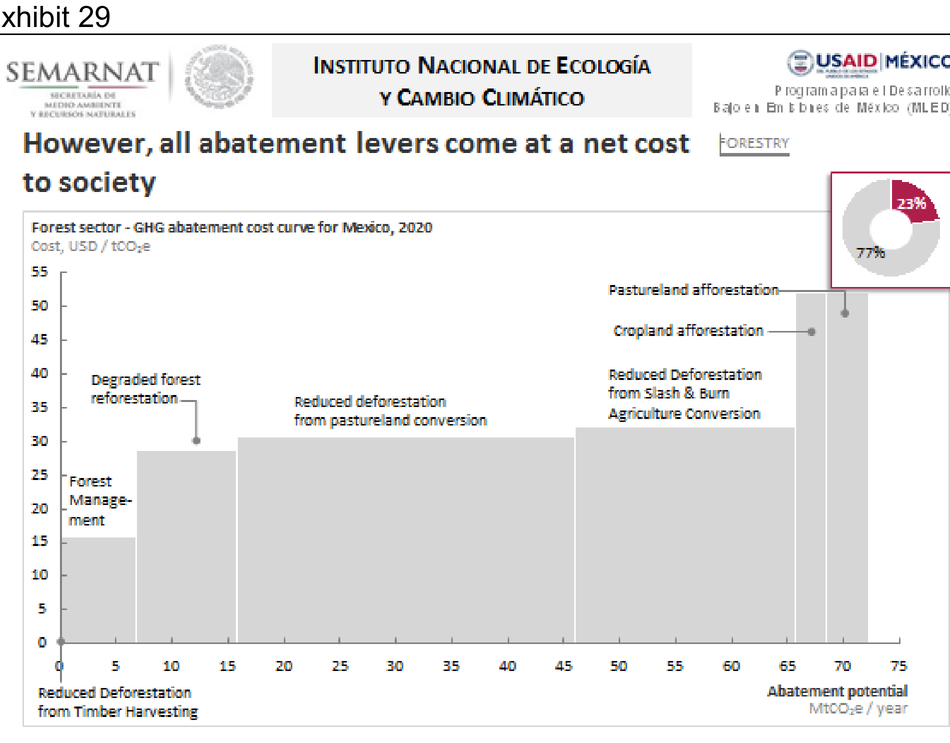
Key assumptions for abatement levers in the forestry sector

Lever	Key volume assumptions	Key cost assumptions
Avoided Deforestation from Slash and Burn Agriculture	• Allocation of total deforestation emissions to Slash and Burn is 32% • Emissions per ha are 90% of biomass and 4% of soil carbon • 90% of deforestation from this activity can be prevented by 2020	• Smallholder households deforest 4 ha/yr • Payment to households is $1900/yr covering income from agriculture
Avoided Deforestation from Cattle Ranching	• Allocation of total deforestation emissions to Cattle Ranching is 49% • Emissions per ha are 92% of biomass and -6% of soil carbon (meaning net soil sequestration from conversion) • 90% of deforestation from this activity can be prevented by 2020	• Ranching profits are 155 $/ ha yr • Recoverable timber volume is 72m3/ha
Afforestation of Marginal Croplands and Pastureland, Reforestation of degraded forest	• Available area for cropland afforestation is total cropland minus cropland in use minus degraded agriculture land (8,40 mha) • All secondary forest (33 mha) is available for degraded forest reforestation • Annual afforestation capacity for cropland and pastureland equals historic deforestation rates. The rate is 0.25mha/year for degraded forest • Sequestration rates per ha are based on INEGEI	• One-time capex and annual management costs are based on U.S. estimates • Payments are matched to carbon flux assuming full repayment of capex and PV of annual expenditures over 30 years of constant sequestration
Forest Management	• All primary forest (32 mha) is available for forest management • Annual management capacity is 0.25mha • Sequestration rates per ha are based on INEGEI	• One-time capex and annual management costs are based on U.S. estimates • Payments are matched to carbon flux assuming full repayment of capex and PV of annual expenditures over 50 years of constant sequestration

SOURCE: Mexico GHG Abatement Cost Curve 2013 129

Exhibit 29



Industry

Overall abatement potential is in the range of 19 MtCO2e, 8% of 2020 BAU. 39% of the abatement (7 MtCO2e) is derived from energy efficiency measures in other industries. 11% of abatement (2 MtCO2e) comprises N20 decomposition of nitric acid in the chemical sector. 11% of abatement (2 MtC02e) comes from BF/BOF to EAF/DRI shift in iron and steel. Around 75% of the industry levers are net profit positive.

N2O decomposition of nitric acid

Applying filtering measures in order to decompose N2O from the tail-gas of nitric acid production, where N2O is produced as a process emission

BF/BOF to EAF-DRI shift, new build

Increased share of EAF-DRI relative to BF/BOF in future steel making

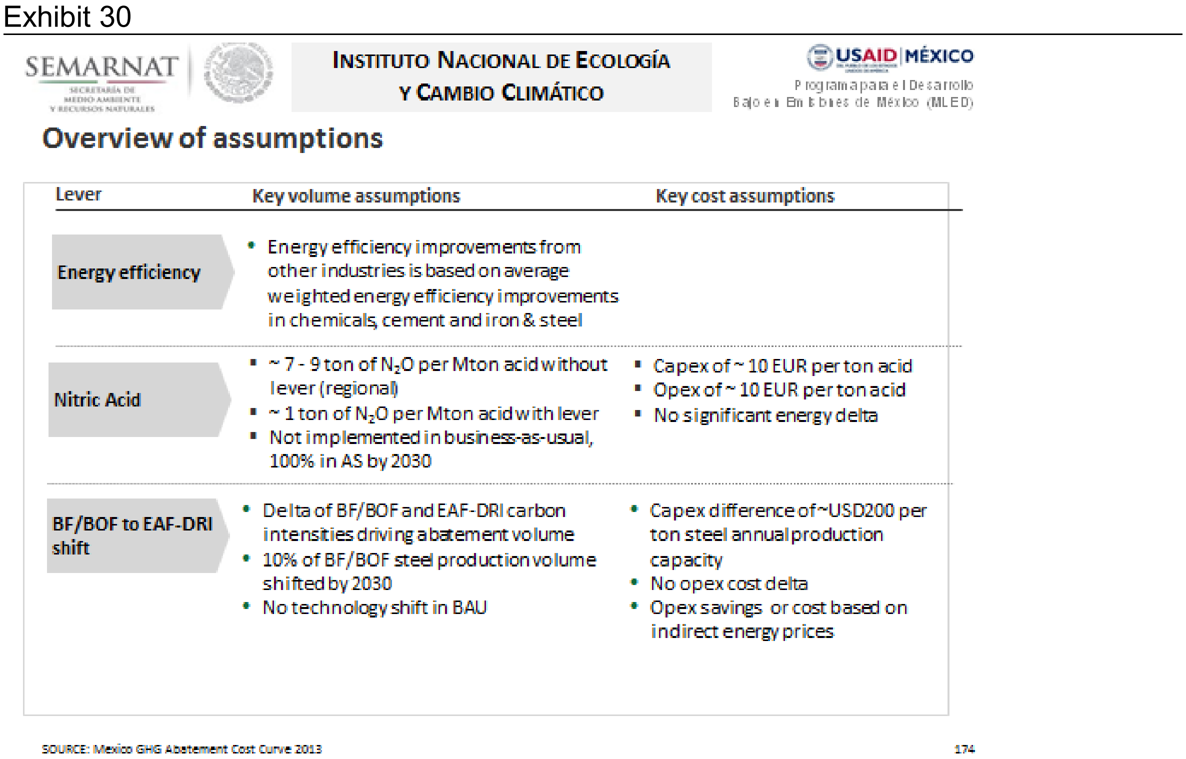
EAF-DRI uses natural gas as fuel in EAF furnaces to produce direct reduced iron (DRI) direct from the iron ore, without the need for scrap metal as a basis for electric arc furnaces

Energy efficiency other industries

Efficient construction in industrial zones cuts emissions.

The key assumptions and results are shown in the below exhibits:

Exhibit 30



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Overview of assumptions

Lever	Key volume assumptions	Key cost assumptions
Energy efficiency	• Energy efficiency improvements from other industries is based on average weighted energy efficiency improvements in chemicals, cement and iron & steel	
Nitric Acid	• ~ 7 - 9 ton of N_2O per Mton acid without lever (regional) • ~ 1 ton of N_2O per Mton acid with lever • Not implemented in business-as-usual, 100% in AS by 2030	• Capex of ~ 10 EUR per ton acid • Opex of ~ 10 EUR per ton acid • No significant energy delta
BF/BOF to EAF-DRI shift	• Delta of BF/BOF and EAF-DRI carbon intensities driving abatement volume • 10% of BF/BOF steel production volume shifted by 2030 • No technology shift in BAU	• Capex difference of ~USD200 per ton steel annual production capacity • No opex cost delta • Opex savings or cost based on indirect energy prices

SOURCE: Mexico GHG Abatement Cost Curve 2013

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Exhibit 31

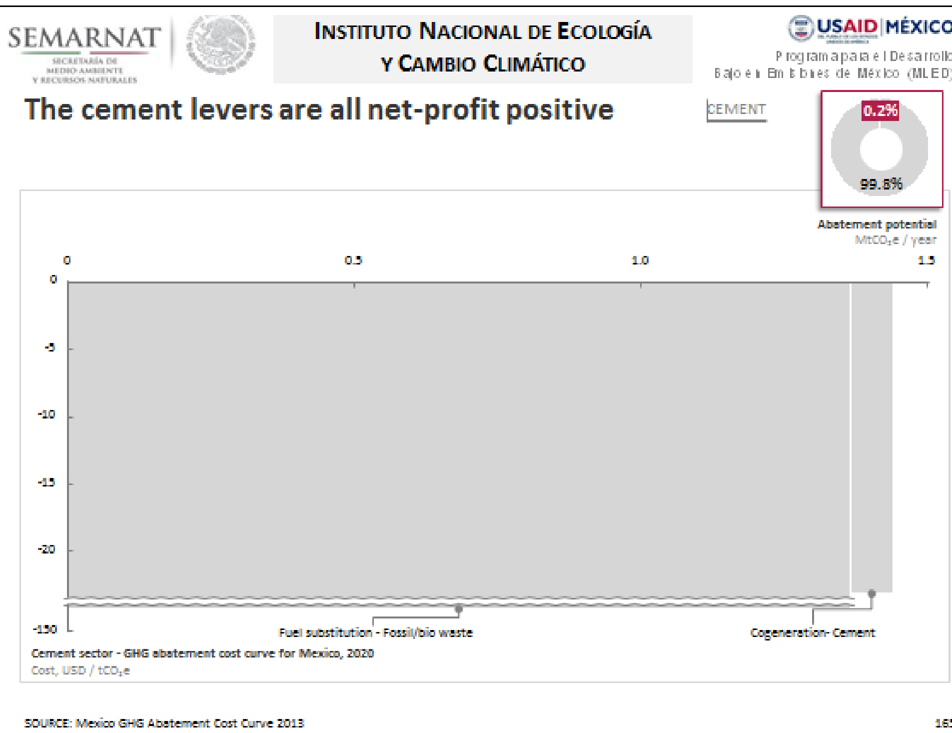


Exhibit 32

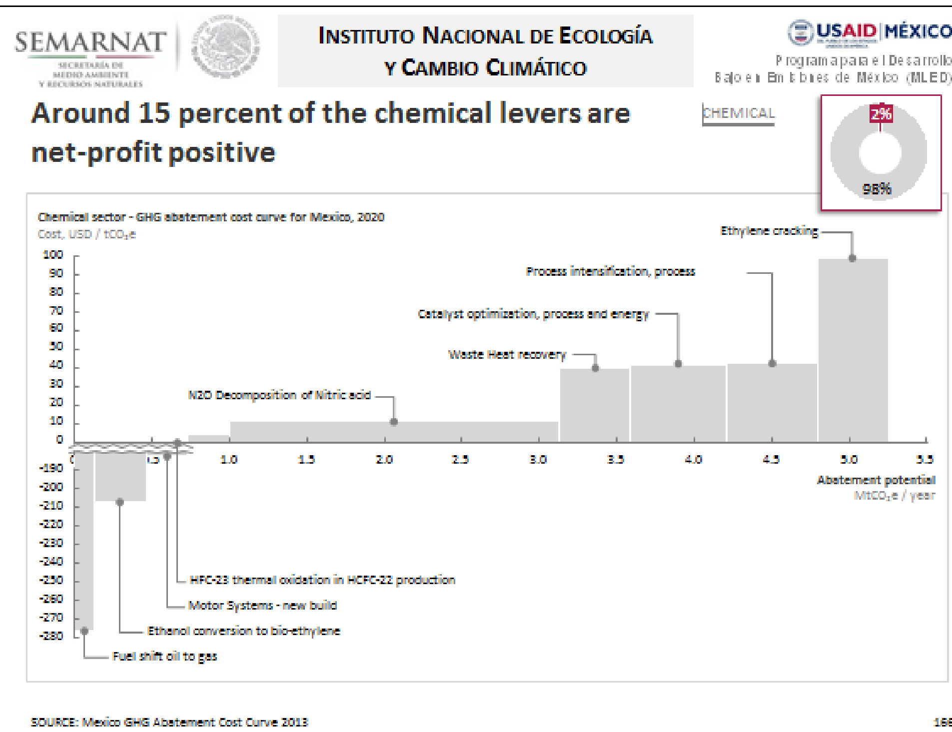


Exhibit 33

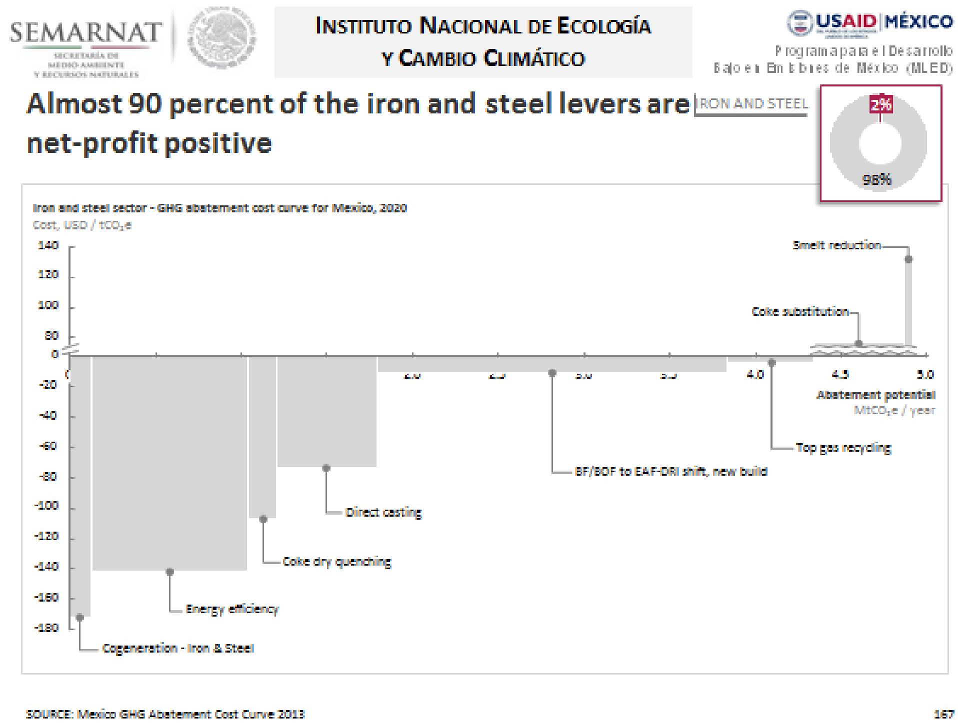
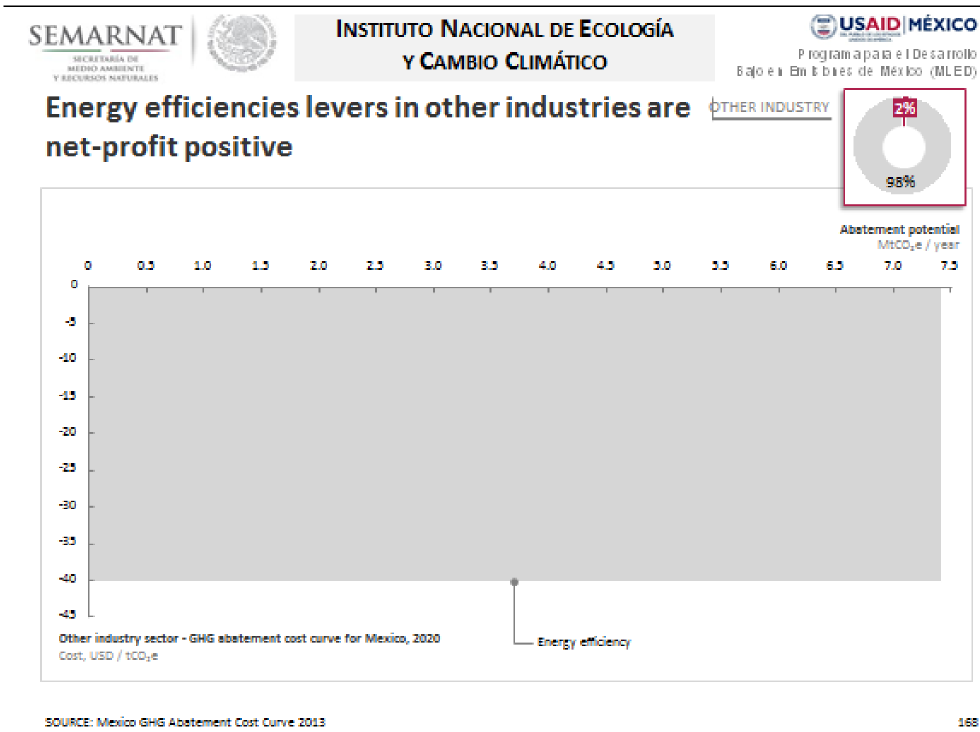


Exhibit 34



Oil and gas

Overall abatement potential is in the range of 47 $MtCO_2e$, 45% of 2020 BAU. 52% of abatement (24 $MtCO_2e$) is derived from reduction in gas flaring either by reinjection or usage. 35% of abatement (16 $MtCO_2e$) comprises cogeneration and other energy efficiency measures in the refineries. CCS in refineries allow for further 6% of the potential. More than 90% of the oil and gas levers are net profit positive.

Reduced flaring—upstream

Measures to reduce continuous flaring by capturing the otherwise flared gas and bringing it to market, which will require; gas recovery and treating units for oil associated gasses, pipeline network to transport the gas

Energy efficiency measures incl. cogeneration

Efficiency measure using combined heat and power generation in which waste heat from power production is used in the refinery

Carbon Capture and Storage (CCS)

In refineries, applying carbon capture and storage to store emissions from power production.

The key assumptions and results are shown in the below exhibits:

Exhibit 35

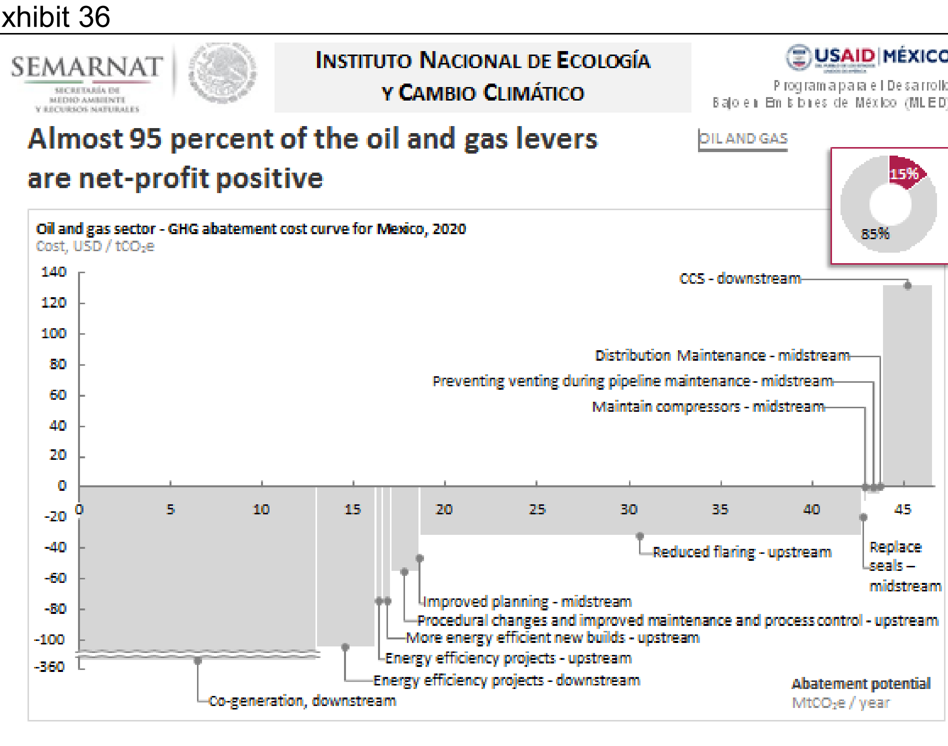
SEMARNAT — Instituto Nacional de Ecología y Cambio Climático — USAID | México, Programa para el Desarrollo Bajo en Emisiones de México (MLED)

Key assumptions

Lever	Key volume assumptions *(source)*	Key cost assumptions *(source)*
Reduction in gas flaring	• Baseline flaring stays constant at 10% of volume *(PEMEX)* • Abatement case flaring is reduced to 2% of volume *(PEMEX)*	• Capex – USD170mn/BCM for the gathering system – 50 km pipe per flare @ $0.3mn/km • Opex estimated at 7% of total vs. capex • Savings result from reduced indirect electricity • Awaiting further input from PEMEX on differences from usage and injection of gas
Energy efficiency measures incl. cogeneration	• Improvement in Solomon Energy Intensity Index from 138.7 today to 90 by 2020. By 2030 the performance is assumed to be at 74, which is equal to global 2013 best-in-class • We assume that the major part of this comes from cogeneration (based on planned projects) and the remaining part will come from other energy efficiency levers	• Normalized CAPEX for a refinery is 0.92 MUSD/MW *(CESPEDES)* • Ratio of OPEX to CAPEX is set to 5% for cogeneration • Ratio of OPEX to CAPEX is set to 50% for other energy efficiency measures
Carbon Capture and Storage (CCS)	• 80% of refineries assumed to be close enough to storage • CCS technically feasible in 80% of sites • 90% of CO_2 emissions can be captured from flue gas	
Other	• The baseline is taken directly from PEMEX	

SOURCE: Mexico GHG Abatement Cost Curve 2013 153

Exhibit 36



Power

Overall abatement potential is in the range of 55 MtCO2e, 36% of 2020 BAU. 31% of abatement (17 MtCO2e) is derived from geothermal power generation. 16% of abatement (9 MtCO2e) comprises small hydro generation. Remaining abatement contribution (29 MtC02e) is from other renewable sources, e.g. wind, reduction of transmission losses and shift within fossil fuels. Around 70% of the power levers are net profit positive.

The key assumptions and results are shown in the below exhibits:

Exhibit 37

INSTITUTO NACIONAL DE ECOLOGÍA Y CAMBIO CLIMÁTICO

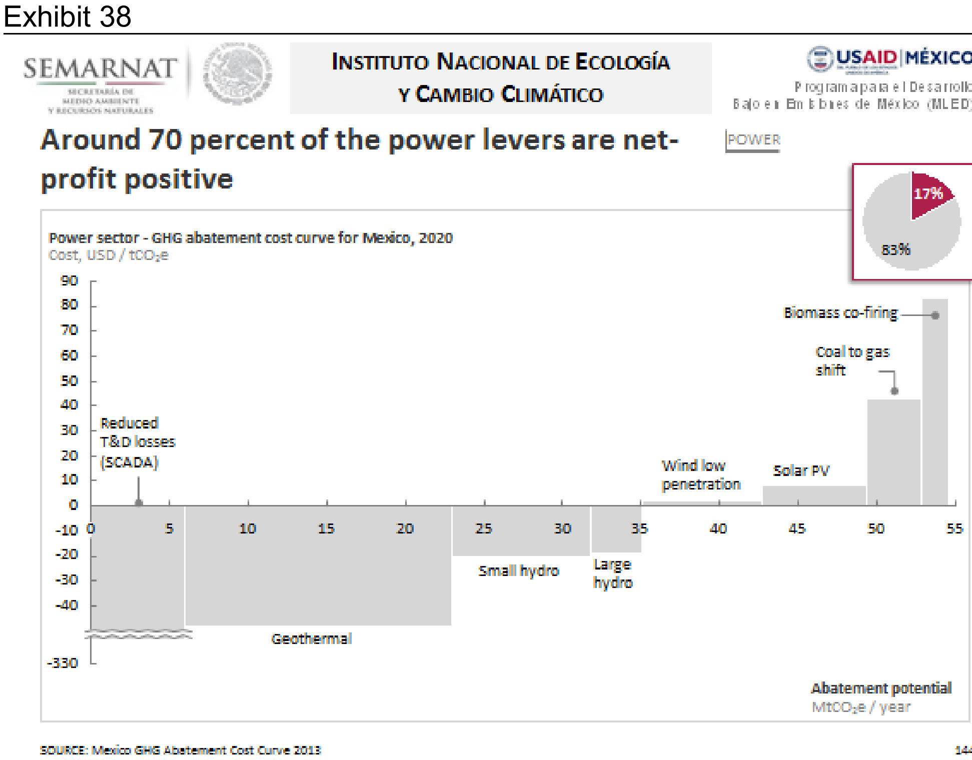
Programa para el Desarrollo Bajo en Emisiones de México (MLED)

Overview of key assumptions

Lever	Key volume assumptions *(source)*	Key cost assumptions *(source)*
Wind low penetration	• Maximum capacity: 30 GW by 2030 *(Prospectiva de las Energías Renovables 2012-2026)* • Uptime: 40 % *(CDM projects)* • Lifespan: 25 years *(Roadmap 2050)* • BAU generation: 10.5 TWh by 2030 *(POISE 2010/2012)*	• Cost of capital : 1425 USD/kW by 2020 *(CDM projects)* • Variable maintenance cost: 7.3 USD/Mwh *(CDM projects)*
Geothermal	• Maximum capacity: 8 GW by 2030 *(Potencial geotermico)* • Uptime: 85 % *(CFE)* • Lifespan: 30 years *(CFE)* • BAU generation: 9.8 TWh by 2030 *(POISE 2010/2012)*	• Cost of capital : 1679 USD/kW by 2020 *(CFE)* • Variable maintenance cost: 8.4 USD/Mwh *(CFE)*
Small hydro	• Maximum capacity: 3.5 GW by 2030 *(Prospectiva de las Energías Renovables 2012-2026)* • Uptime: 55 % *(CDM projects)* • Lifespan: 25 years *(CDM projects)* • BAU generation: 0.3 TWh by 2030 *(POISE 2010/2012)*	• Cost of capital : 2088 USD/kW by 2020 *(CDM projects)* • Variable maintenance cost: 7.5 USD/Mwh *(CDM projects)*
Large hydro	• Maximum capacity: 25 GW by 2030 *(CFE)* • Uptime: 36 % *(CFE)* • Lifespan: 50 years *(CFE)* • BAU generation: 57.8 TWh by 2030 *(POISE 2010/2012)*	• Cost of capital : 2092 USD/kW by 2020 *(CFE)* • Variable maintenance cost: 5.4 USD/Mwh *(CFE)*
Solar PV	• Maximum capacity: 26 GW by 2030 *(Estimation)* • Uptime: 25 % *(IBID - prospectiva)* • Lifespan: 25 years *(CDM projects)* • BAU generation: 0.0 TWh by 2030 *(POISE 2010/2012)*	• Cost of capital : 1000 USD/kW by 2020 *(Darkest before dawn)* • Variable maintenance cost: 3.5 USD/Mwh *(Darkest before dawn)*
Other	• The total share of intermittent technologies, incl. small hydro, solar, wind can max be 28% of total generation • The baseline is based on the 2010 POISE mix and 2012 generation forecast. This is a green baseline	

SOURCE: Mexico GHG Abatement Cost Curve 2013 146

Exhibit 38



Transport

Overall abatement potential is in the range of 55 MtCO2e, 20% of 2020 BAU. 54% of abatement (30 MtCO2e) is derived from fuel efficiency measures primarily targeting LDVs. 24% of abatement (13 MtCO2e) is driven by modal shifts to public and freight transport. 15% of abatement (8 MtCO2e) comprises policy measures, i.e. vehicle mix, scrapping program and ban of imported cars.

Around 70% of the transport levers are net profit positive. The key assumptions and results are shown in Exhibits below:

Exhibit 39

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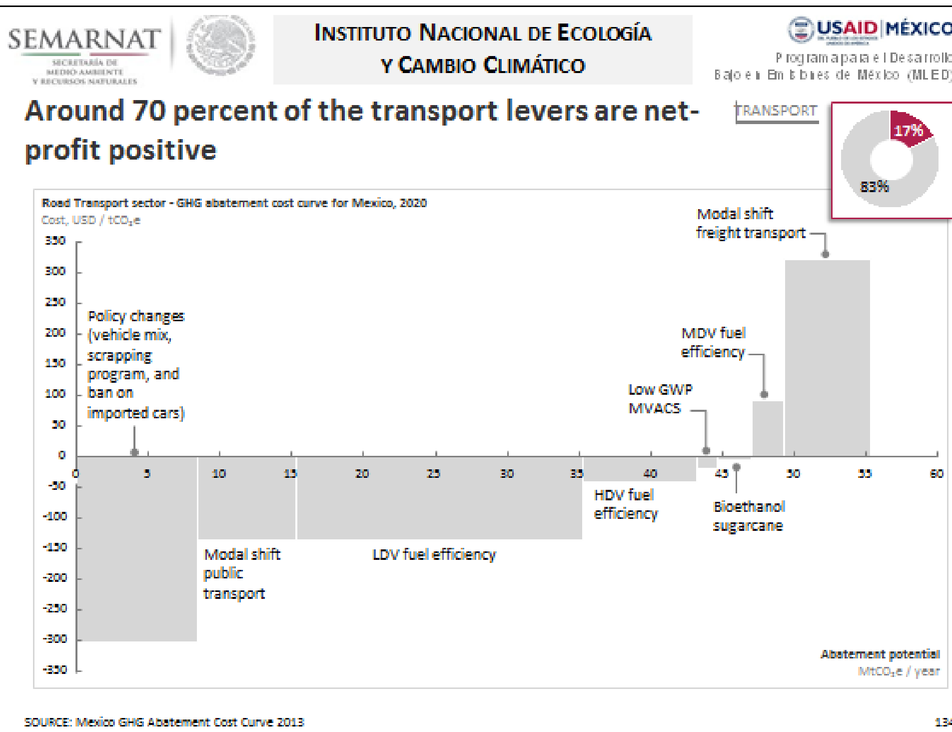
Key other assumptions

Lever	Key volume assumptions	Key cost assumptions (*sources*)
Other/fuel efficiency	▪ Number of vehicles on road increases from 23.6 million in 2010 to 38 million in 2020 and 62 million in 2030 (main driver of BAU emissions) ▪ Fuel efficiency stays constant in BAU ▪ LDV fuel efficiency improvements are closely linked to policy standards to 14.9 km/l; 17.7 km/l and 23 km/l by 2015, 2020 and 2025 respectively	▪ Included in previous pages
Policy change (vehicle mix, scrapping program, and ban on imported cars)	▪ 80/20 mix of LDV vs. MDV in new sales by 2020 (90/10 by 2030) ▪ Reduction of LDV, MDV, and HDV vehicle lifetime in years from 15, 20, 20 to 10, 15, 15 respectively ▪ Replace 1.3 million imported cars with 400k domestic ones	▪ The levers only calculate changed OPEX, e.g. a reduction in fuel consumption
Modal shift (passenger vehicles to public transport and HDV shift to rail)	▪ Share of passenger kilometer shifting to buses (2020): 4% ▪ Share of passenger kilometer shifting to BRT (2020): 5% ▪ Share of passenger kilometer shifting to metro (2020): 1% ▪ Share of freight ton kilometer shifting to trains (2020): 10%	▪ O&M cost per passenger km in brt: 0.02 USD/passenger-km (*Insurgentes BRT*) ▪ O&M cost per ton km in trains: 0.04 USD/ton-km

SOURCE: Mexico GHG Abatement Cost Curve 2013 — 139

Exhibit 40



Waste

The abatement levers in the waste sector cut CH4 and N2O emissions. These emissions can be reduced by reducing the quantity of waste in landfills through recycling the quantity of waste in landfills through recycling or using some of the waste for fertilizers; producing energy from decomposed waste products—for example collecting the gas emitted from buried waste for electric power generation. Overall abatement potential is in the range of 44 MtCO2e, 61% of 2020 BAU. 51% of abatement (23 MtCO2e) is from recycling of new waste. 28% of abatement (12 MtCO2e) comprises improved waste water treatment. 20% of abatement (9 MtCO2e) comes from landfill gas electricity generation. Around 70% of the waste levers are net profit positive.

Landfil gas electricity generation

Methane is produced and emitted from the anaerobic decomposition of organic material in landfills. Main drivers of emissions are the share of organic waste, the wetness of the system, the weather and the design of the landfill.

Recycling new waste

Recycle raw materials (e.g., metals, paper) for use as inputs in new production. Reducing the quantity of buried waste reduces the total quantity of waste that is likely to emit GHGs as well as the additional emissions required for the production of new materials.

Wastewater - improved treatment

Organic material in the waste water produces methane when it decomposes anaerobically. Particularly acute in developing countries with little or no collection and treatment of wastewater and anaerobic systems are more prevalent.

The key assumptions and results are shown in exhibits below -

Exhibit 41

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Key assumptions

Lever	Description	Key volume assumptions *(source)*	Key cost assumptions *(source)*
Electricity generation from landfill gas	• Capture landfill gas to generate electricity	• LFG electricity generation is limited to the 30 largest cities in Mexico consuming 50% of waste. 50% of the 30 cities will have LFG plants by 2020 • Gas capture rates over the lifetime of the landfill is assumed to be 50%	• Capex: 112 per tCO2e of abatement capacity *(CDM projects)* • Opex: USD 8 per tCO2e *(CDM projects)* • Revenues from energy sales: USD 82 per tCO2e *(CDM projects)*
Recycling	• Recycle raw materials (e.g., metals, paper) for use as inputs in new production	Abatement potential • Paper: 5.2 tCO2e per ton • Plastic: 1.8 tCO2e per ton • Glass: 0.4 tCO2e per ton • Metal: 7.7 tCO2e per ton Share in waste (Diagnostico basico) • Paper: 14% • Plastic: 11% • Glass: 7% • Metal: 5%	• Capex for Recycling per tonne of waste processed: USD 16 per tCO2e • Opex for recycling per tonne of waste : USD 16 per tCO2e • Revenues from recycling : – Paper: USD 80 per tCO2e – Plastic: USD 160 per tCO2e – Glass: USD 20 per tCO2e – Metal: USD 1200 per tCO2e
Waste water treatment	• Improved waste water treatment	• Address all industrial and municipal waste water • Waste water treatment is limited to a technical emission reduction potential of 45% by 2020	• Capex: USD 14 per tCO2e of abatement capacity • Opex: USD 162 per tCO2e

SOURCE: Mexico GHG Abatement Cost Curve 2013

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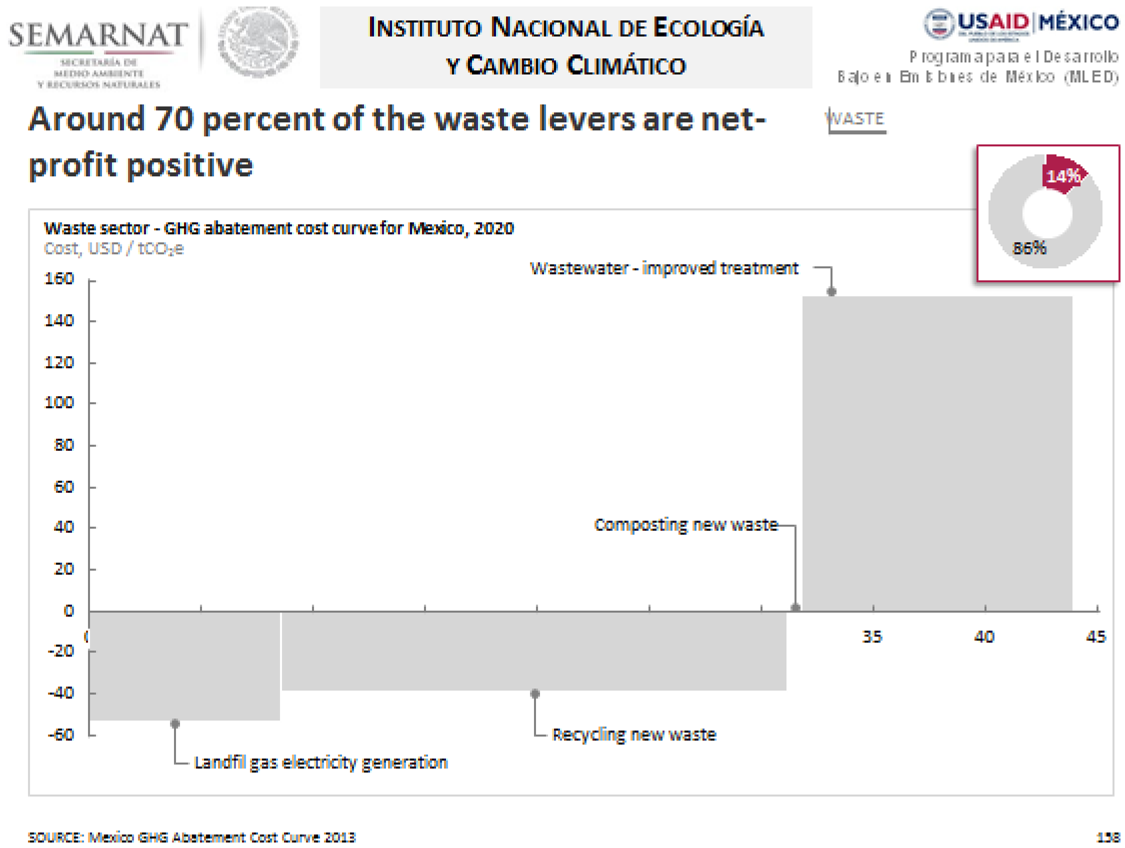
Exhibit 42



Appendix Three: Project portfolio tracker

The following pages introduce some of the projects that have been documented in the project portfolio tracking tool. Please refer to the attached power point file for the full version of all 81 project templates.

Exhibit 43

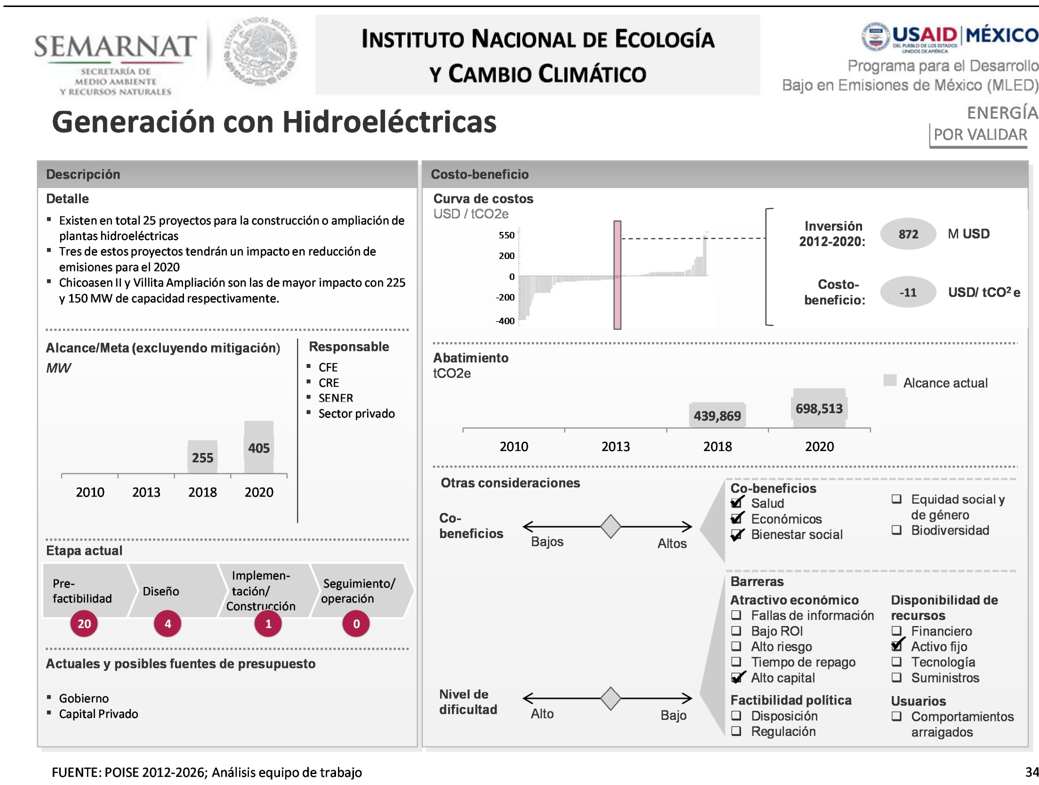


Exhibit 44

Exhibit 45

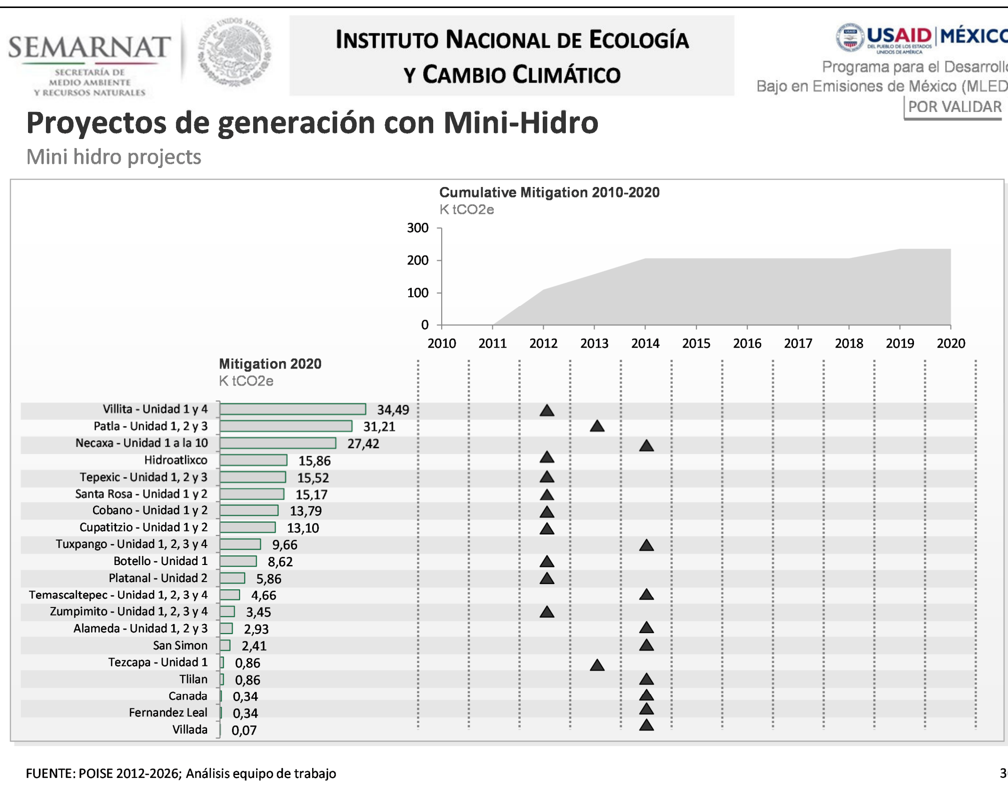


Exhibit 46

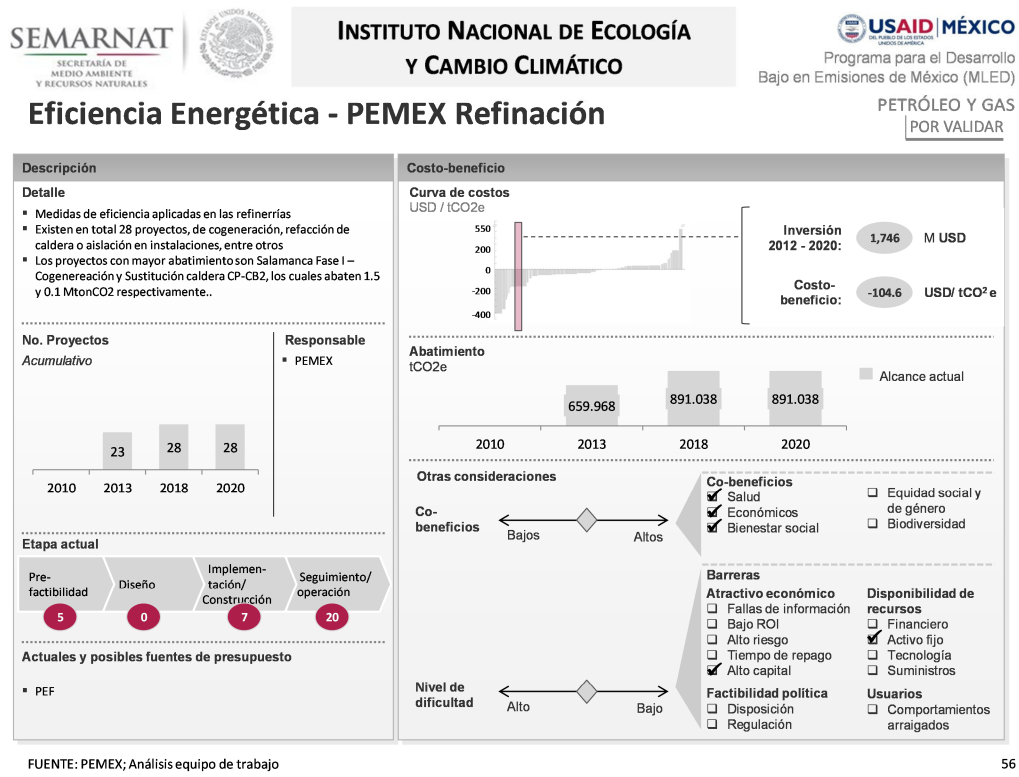


Exhibit 47

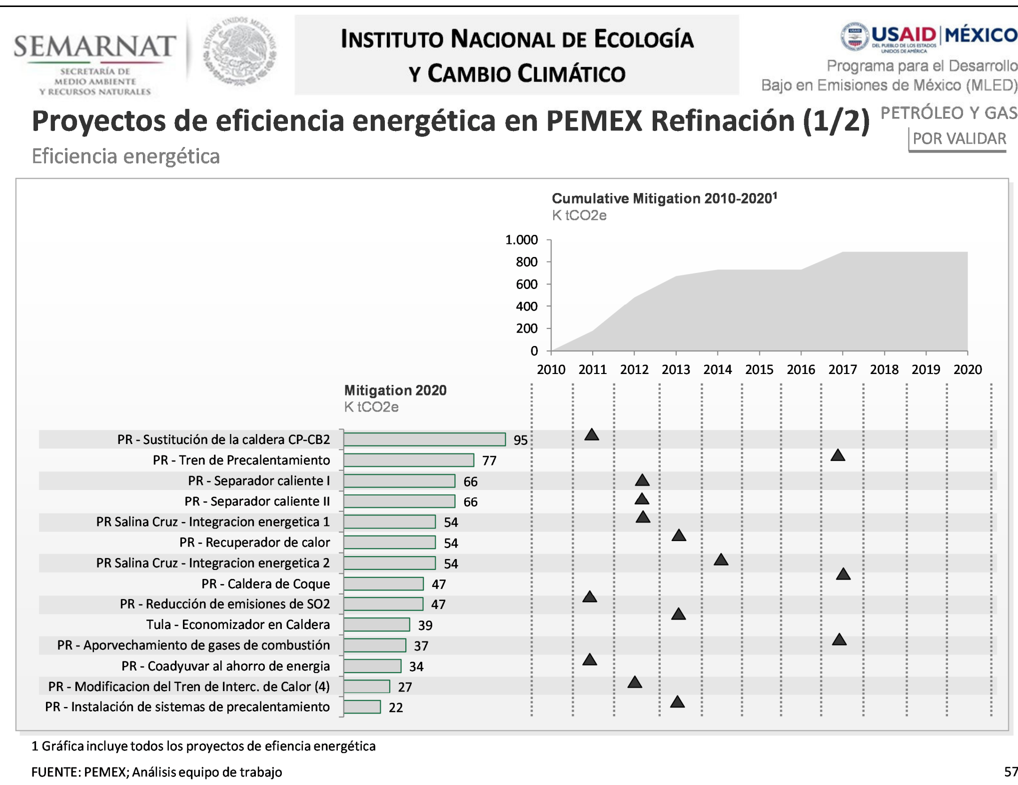


Exhibit 48

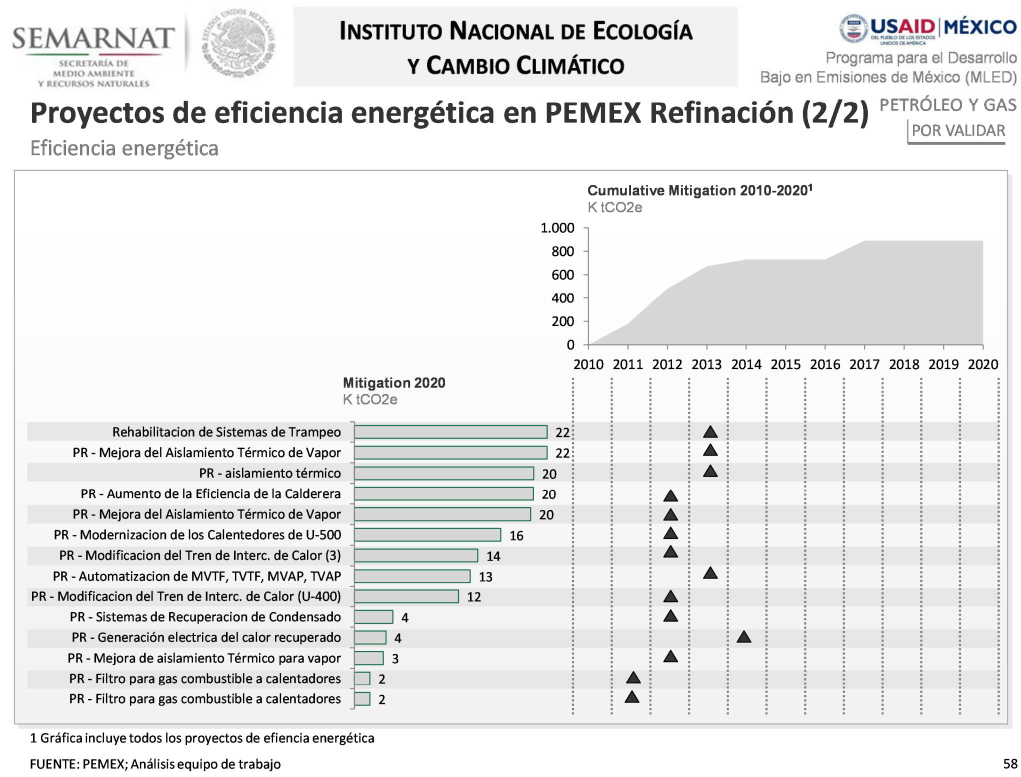


Exhibit 49

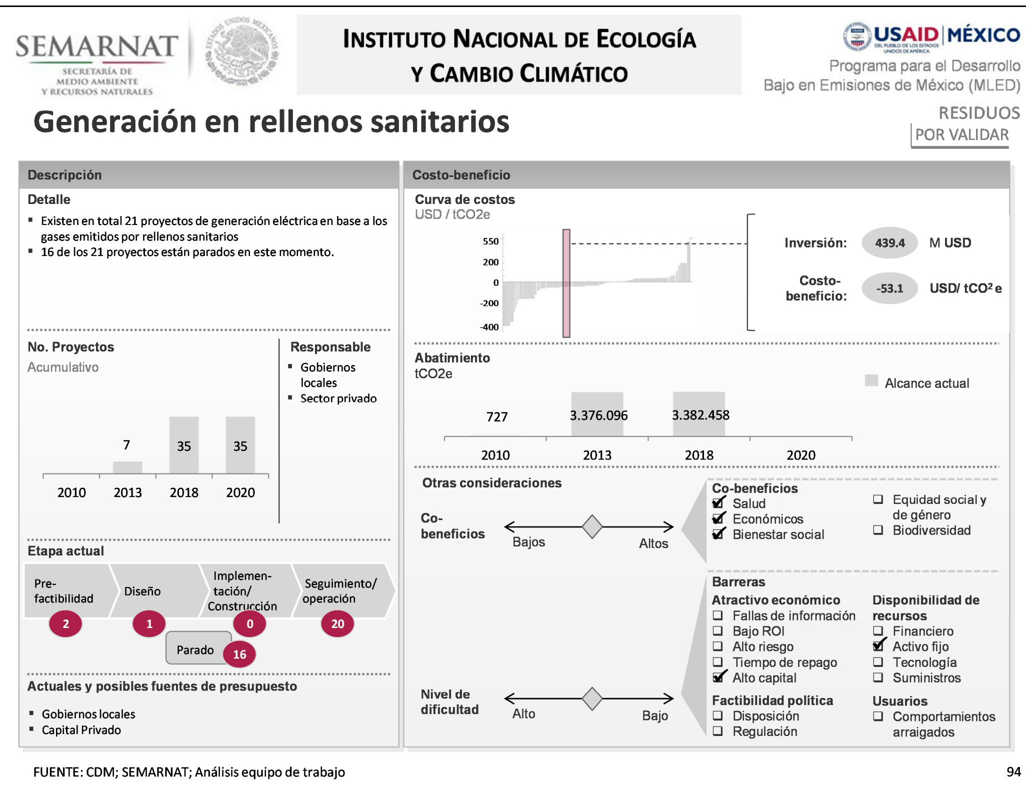
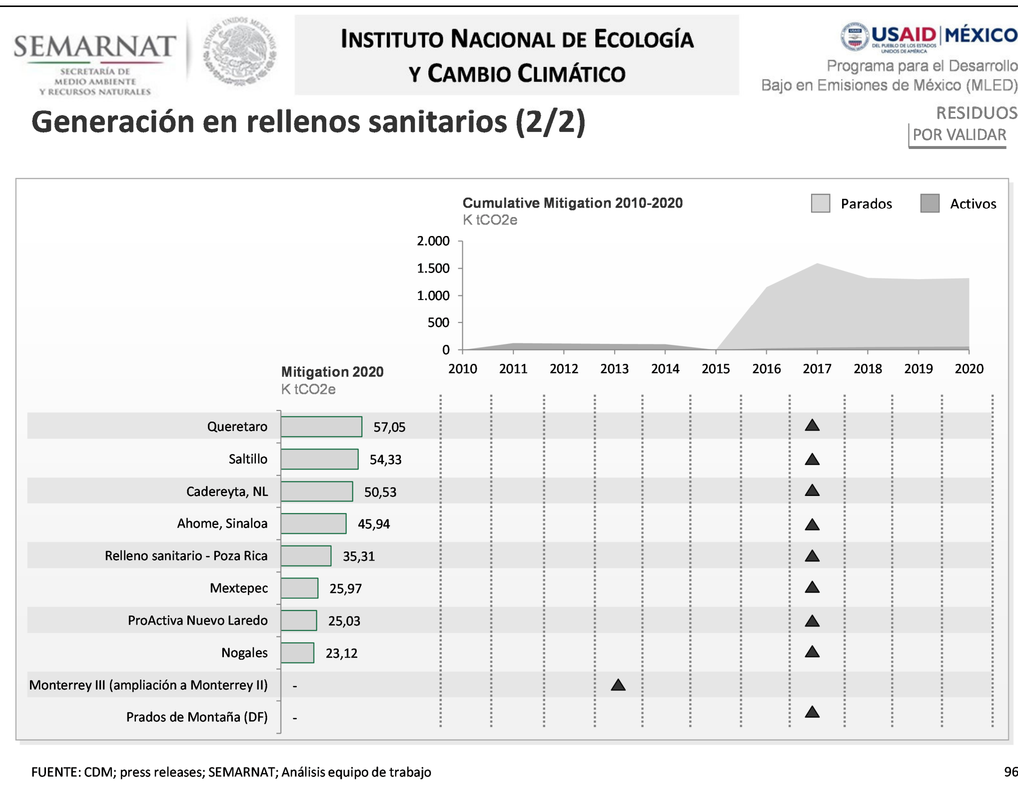


Exhibit 50

Exhibit 51



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